COAL MINING AND THE
COAL MINER

EXPLORER EQUIPPED WITH WEG APPARATUS PASSING THE [illegible] OF EXPERIMENTAL GALLERY

EXPLORER EMERGING FROM AIR PIPE [illegible] FEET IN DIAMETER

COAL MINING
AND
THE COAL MINER

BY

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WITH TWENTY-TWO ILLUSTRATIONS

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PREFACE

THE coal-mining industry is unique, or at least outstanding in several ways—in the paramount importance of coal to the modern life of civilized peoples; in its great value as our chief source of power and light and heat, and of many much needed substances such as benzol and ammonia, and the appalling wastefulness of many of our present methods of using it; in the dangers and difficulties and the seclusion in which the coal miner works; in the prominent position which he occupies in the labour movement; in the attention which the industry receives from the legislature; in its close connection with engineering and scientific progress and development.

These are some of the more engrossing features of the subject which it has been sought to bring out in this book.

As the war has so greatly upset the normal condition of the industry, figures and statistics relating to the number of persons employed, output, wages, accidents, etc., have been confined for the most part to the period before the war, terminating with 1913 as the last full year.

On the various matters dealt with, the author has tried to give the best expert opinion and practical results obtained up to date. This entails perhaps a redundancy of quotation and reference, but knowing the authority the reader can better gauge the value of the statements made.

The book was written before the Coal Commission commenced its novel proceedings. That Commission and its findings are the outcome of an altogether abnormal state of the industry, arising from the five years of the war, and the Government control then instituted.

This book describes the conditions in normal times of peace, which happily prevail, and it may perhaps serve as a useful corrective to some erroneous ideas, which have arisen from the proceedings of the Coal Commission.

Having been a colliery manager, and a director of colliery companies, and having lived for many years amongst working miners, the writer knows and appreciates their work and their sterling qualities. Certainly they deserve to be well paid, well housed, and not overworked.

The miners' representatives on the Coal Commission did their best to create prejudice very unfairly against colliery owners, by blaming them for the bad housing of the miners. The truth is that colliery owners, most of whom it should be remembered are small shareholders, have done more than most employers to provide houses for those they employ. It was given in evidence before the Coal Commission that during the ten years 1904–14, there was spent in purchasing, or in building, or in improving miners' houses in Durham and Northumberland, £2,567,000.

The instances given in this book, and many more might be added, show that until the war stopped progress, much had been done and was being done to provide good houses with pleasant surroundings in nearly all the mining districts of the country. The dimensions and accommodation of the houses, with the cost of building them and the rents charged for them, are given in some detail at the risk perhaps of wearying the general reader, but with the view of supplying full information to those who have to provide houses of this type.

With respect to colliery profits—to pick out the plums as a sample of the whole pudding is simply misleading, and so it is also to take results of a period of prosperous years, and to ignore the lean years.

The truth, as the reader of this book may learn, is that the return received on the capital invested in collieries over the whole is very moderate, and less than that obtained in many other industries.

The author wishes to acknowledge with grateful thanks the help he has received from many colliery managers and others, especially in connection with the subject of miners' houses.

It is hoped that the book may be of some service in the difficult period of industrial reconstruction on which we have entered after the war.

H. F. BULMAN

July 2, 1919

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COAL MINING
AND THE COAL MINER

CHAPTER I

THE COAL MINER AND HIS WORK

"VENERABLE to me is the hard hand, venerable too is the rugged face. Is it not the face of a man living manlike? Hardly entreated brother! For us was thy back so bent! For us were thy straight limbs and fingers so deformed! Thou wert our conscript, on whom the lot fell, and fighting our battles thou wert so marred!"

Much has been done to alleviate the conditions under which the miner works, since Carlyle wrote these words, but they still strike a responsive chord in the breasts of many who are interested in the miner and his work. It is impossible to appreciate the coal miner properly, until one has seen him frequently at his work in its more arduous aspects. Darkness and dirt, poisonous and inflammable gases, falling stone, volumes of rushing water, a murky and dusty atmosphere, and in the deeper mines exhausting heat —these are the *natural* surroundings amid which coal has to be won from the crust of the earth. Mining in its primary operation of excavating the solid strata is a slow and laborious process, and every foot won has to be maintained against the constant and sometimes overwhelming pressure of the surrounding strata. This constant pressure causing falls of roof and sides is an ever-present and far the most deadly source of danger. All the natural conditions are harsh and repellent, and nature has no consideration for ignorance or weakness or mistakes. Mining is a constant tussle with difficult and dangerous conditions.

Difficulty and danger have their allurement for the heart of man, and achievement in the teeth of obstacles affords the highest satisfaction—*Res severa est verum gaudium*—but apart from this, there is no glamour about coal mining, no shouting or applause, no waving banners or stirring music.

The miner carries on his daily work in the bowels of the earth

"Without the sense or sight
Of day or the warm light."

His daily work necessarily sets its mark on a man and helps to mould his character and to colour his general outlook on life.

The typical coal miner is not always an attractive individual on the outside, but an uncouth and unprepossessing exterior often hides a strong and resolute character and a kindly disposition. Accustomed to face stern and disagreeable realities in his daily work, he is real and genuine in his feelings and conduct, and has a robust individuality of his own. Self-reliant and independent, he is no respecter of persons, but his respect, once gained, is sincere and lasting.

Of course there is much variety of individual character and conduct amongst miners. The roughest specimens are usually to be found at new collieries, where there is a demand for men, and every one who comes is taken on. It is remarkable what a much better tone prevails as a rule in long-settled communities who have lived in the same place and worked at the same colliery for two or more generations. In such communities men and women of an admirable type are often to be found.

Strenuous work with liability to danger tends to sharpen a man's faculties and energies, and the miner is usually a virile and wide-awake sort of person. Of all classes of labour, he is the most grasping and the most combative, the sturdiest fighter in the industrial field, always asking for more. The qualities which his calling specially demand are physical strength and hardihood, pluck and grit and alertness, and that many miners excel in these qualities has been proved by the war. In the words of Sir John Simon, when, as Home Secretary, he presided at the coal mining conference held at the London Opera House on July 29, 1915: "The mining industry had responded splendidly to the appeal for recruits. Whole regiments had been recruited from the colliery districts up and down the land. He had been assured by soldiers the most eminent that the miners carried to their work in the firing line the bravery and determination that actuated the industry throughout the country. In at least one military unit practically every private was a pitman, every officer and non-commissioned officer was connected with a colliery, and the commanding officer was one of H.M. inspectors of mines. The miners had given to Kitchener's Army a quarter of a million men." Before the end of the war this number had increased to 400,000.

We have it on the authority of the Commander-in-Chief, Sir Douglas Haig, that there were no more gallant or enduring men than the miners when they got to France. As a writer in the *Times* puts it: "The miner, as a rule, makes an excellent fighting man. He is not of imposing stature, but he is tough and fearless. The pit has no mercy for the weedy or the timid. It calls for strength and stamina."

The war has shown up in a strong light both the good and the bad sides of the British coal miner. A large proportion of those of fighting age voluntarily answered the call of the country and have done admirable service as soldiers at the front; whilst too many of those at home seem to have been actuated by the idea that the cause of Labour, or the interests of their own class, justify any means to achieve their ends. In spite of the urgent national need for coal, there have been far too many instances of strikes for which there was no reasonable justification.

Writing to the Secretary of the Miners' Federation in June 1918, the Controller of Coal Mines stated that "The loss of coal output from sporadic strikes, caused by differences which could easily have been settled without resorting to this weapon, has been very great."

They show their best side as individuals and their worst when acting together in a corporate capacity, being sometimes misled and misrepresented by their noisiest spokesmen. It is not unusual to see individual excellence co-existing with corporate mediocrity!

The temperament of a good many of the miners is illustrated by an old story of the reply made by one of them during a strike. A visitor to the village where the strike was proceeding got into conversation with one of the men, and asked him what they were striking for? what it was they wanted? The reply was: "I'm d——d if I know what we want, but we're going to get it!"

Owing largely to the distinctive character of their work, and to the fact that they live together in isolated communities without much admixture of other classes, the miners have developed a strong class feeling of their own. They have been pioneers in the chief labour movements, and have always produced capable leaders from their own ranks, who push their interests in Parliament and elsewhere.

An outstanding example is the Right Honourable Thomas Burt, D.C.L., the first working miner to be sent to Parliament. He represented Morpeth for forty-four years—from 1874 till he retired at the general election in December 1918—and became the father of the House of Commons. He was Under-Secretary of the Board of Trade from 1892–95, and was made a Privy Counciller in 1906. At ten years of age he was working twelve to thirteen hours a day as a "trapper"[1] boy at Haswell Colliery, County Durham. For eighteen years he was a working miner, till at the age of twenty-eight he was elected, somewhat against his natural inclination, to the post of secretary to the Northumberland Miners' Union, and thus began his useful and admirable public career. He has done as much as any man to promote the best interests of Labour, and always by methods of reason and goodwill.

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[1] A boy employed in opening and shutting ventilation doors to allow the passage of coal tubs on underground roads.

The miners exert stronger political influence than any other body of hand-workers. The leader of the Opposition in the new Parliament of 1919 is a Scottish miner, who worked in the pit for twenty-seven years. The miners have the largest representation in the House of Commons of any class of industrial workers. Of the whole Labour group in the new Parliament about half have worked in mines.

CHAPTER II

LABOUR EMPLOYED IN COAL MINING

THERE were employed in the year 1913 at the 3121 coal mines at work in Great Britain and Ireland 1,110,884 persons[1]; 895,857 of them, or 80·6 per cent, were working underground. Of these underground workers, 844,852 were adults above 16 years of age, and 51,005, or 5·69 per cent of them were boys under 16; 21,533 boys were employed on the surface, of whom 16,016 were between 14 and 16 years of age, and 5517 under 14. The total number of boys employed at coal mines was thus 72,538. Of the 215,027 surface workers, 6554, or 3·04 per cent, were females, 911 of them being girls from 14 to 16 years of age, and 31 under 14. It is chiefly in Scotland and in Lancashire that women and girls are employed in surface work.

The expansion of the coal-mining industry is shown by the fact that the number of persons employed has more than doubled during the thirty years, 1883 to 1913, the number in 1883 being 514,933.

Compared with other industries, coal mining is remarkable for the large amount of manual labour it requires. The "dead work" that has to be done is large in proportion to the "useful work" of getting coal. Man power still plays the major part in the production of coal, though mechanical power is being increasingly used. For a daily output of 1000 tons of coal, under average conditions of

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[1] These figures include all mines from which coal is obtained, whether alone or together with other minerals, such as ironstone, fireclay, etc. The figures are a little lower than those for all mines coming under the Coal Mines Act, as these include ironstone mines, in which no coal is produced.

British coal mining, 800 to 850 men and boys are required. This includes surface hands. The average daily output per person employed *underground* runs generally from 1 to 1½ tons.

The cost of labour is much the largest item in the total cost of producing coal, forming about 70 per cent of it, and it has been increasing steadily for a good many years past.

The economical employment and arrangement of labour—"scientific administration," as it is sometimes called—is of the first importance in the efficient working of a colliery. The "useful result" is the production of coal, and the best test of efficiency is the production per person employed per hour worked. All the organization of men and machinery should be directed to securing the largest possible output per man. The lower the production per man, the higher will be the cost per ton. "The only way to increase prosperity is to increase the net output per head of the workmen employed" (Coal Conservation Committee Report, 1918).

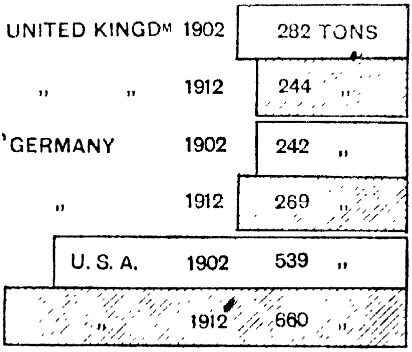
Unfortunately, the restrictive policy of the Trade Unions, and the effect of recent legislation, have lowered the production and reduced the efficiency, in spite of the increasing adoption of improved appliances, such as coal-cutting machines, face conveyors, and auxiliary haulage motors.

The reduced output per person employed has been very marked during the five-year period—1909 to 1913—subsequent to the passing of the Eight Hours' Act, 1908.

Five-Year Periods.	Average Yearly Output per Person employed Underground.
1894-98	367 tons
1899-1903	372 ,,
1904-1908	363 ,,
09-1913	328 ,,

The last five years, however, include 1912, the year of the six weeks' national strike. Eliminating 1912, the average for the four years is 333 tons, or 30 tons less than during the preceding five years, and 42 tons less than during the period 1899 to 1903. (See evidence of Mr. H. Johnstone, H.M. Inspector of Mines, before Coal-mining Organization Committee, 1915.)

The accompanying diagram taken from a *Times Trade Supplement* shows how the output per man in the United Kingdom has fallen during the decade 1902–12, whilst it has risen in Germany and the United States.

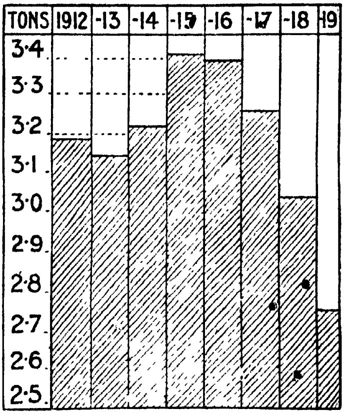


Output per person employed below and above ground in the three principal coal-producing countries.

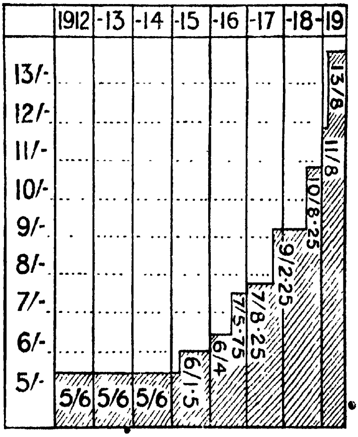
It is an unfortunate fact that increased wages have been accompanied by reduced output per man. This is well shown in the accompanying diagrams which appeared in the *Newcastle Daily Journal* of August 9, 1919. They are based upon the averages for the whole of the Associated Collieries of County Durham, during the eight years 1912 to 1919. It will be seen that the highest output per hewer per shift worked was in 1915, when it averaged 3·4 tons, and the minimum wage was 6s. 1·5d. In 1919 this minimum wage has risen to 13s. 8d. per shift, and the average output per hewer has fallen to 2·7 tons. During these years 1915 to 1919 the minimum wage has increased 123 per cent. whilst the output has fallen 20 per cent!

The highest possible production per person employed implies that each is engaged on the work for which he is best fitted and is doing his best. It implies that the roads and the working faces of the mine are so laid out as to allow of the most profitable employment of labour, and also that the most suitable mechanical appliances are in use. Thus it is the best test of efficiency, and efficient working will be always the safest and the most economical.

OUTPUT PER HEWER PER SHIFT WORKED.



MINIMUM WAGE.



"It is only by increased production per head of the persons employed that our trade position can be maintained, and that improved conditions of employment can be secured, and this ought to be recognized by workmen as well as by employers" (Coal Conservation Committee Final Report, 1918).

The value of scientific management may be illustrated by an example given by Dr. Charles S. Myers in his *Present-Day Applications of Psychology*. Five hundred shovellers were employed in shovelling material of very varying weight—sometimes coal, sometimes ashes, at other times heavy iron ore, etc. It was found by experiment that the best average weight per shovel load for a good shoveller was 21 lb. Accordingly shovels were made of different sizes, so that when loaded, whatever the material—each shovel with its load weighed 21 lb. "This was the most important innovation, although others were at the same time carried out. The results were as follows: (1) The average amount shovelled per day rose by nearly 270 per cent.—from 15 to 59 tons per man; (2) 150 men could now perform what 500 men had performed under previous conditions; (3) the average earnings of the shovellers increased by 60 per cent; (4) the cost to the management, after paying all extra expenses, was reduced by 50 per cent; (5) there was no evidence of increased fatigue of the shovellers."

The labour employed at a colliery may be considered under five heads, viz. that required for

(1) Getting the coal and filling it into tubs at the coal face.

(2) Transporting the coal from the face to the surface.

(3) Making and repairing roads, and maintaining the mine in good working order.

(4) Cleaning and screening the coal on the surface, and putting it into trucks.

(5) Tending and maintaining engines and mechanical appliances and buildings—for which enginemen, stokers, fitters, joiners, masons, and mechanics of various sorts are needed. A modern coal mine is full of machinery. There are coal cutters and mechanical conveyors at the face; hauling engines and pumping engines at various points of the workings; long lengths of electric cable with switch boxes and fuses; miles of hauling ropes running on sheaves and rollers; signalling wires; pipes for conveying water and compressed air; miles of railway; and hundreds

of coal tubs. All this equipment has to be maintained in working order under difficult natural conditions of darkness and dirt, and the constant pressure and movement of the surrounding strata.

1. The labour required in the getting of the coal and filling it into tubs necessarily varies a great deal according to the nature of the coal seam—its hardness and thickness and structure.

For instance, the hard and thin coal seams of Northumberland are very different from the thicker and softer steam coal seams of South Wales. The latter are full of smooth partings known as "slips," extending right through the seam from floor to roof, and are therefore much easier to hew, requiring no undercutting or "holing," and, as a rule no blasting or shot firing.

Similar differences exist in all the coal-fields of the country.

In the Northern coal-field (Northumberland and Durham) there is more division of labour in the coal face than in most of the other districts. The work of the hewers is confined almost entirely to the hewing of the coal and filling it into tubs. It is strenuous work, and their hours are short, not more, as a rule, than five and a half hours in the face. Other men set the timber to support the roof, and lay the railway for the coal tubs; and others, again, remove stone to make height, and build pack walls to take the top weight.

In other districts all this work in the face is done by the same men.

Sometimes, again, three sets of men are employed: (1) Holers, who do the "holing" or undercutting of the seam; (2) getters, who bring down the undercut coal by drilling holes and firing shots as required; (3) fillers, who fill the fallen coal into tubs.

Where coal-cutting machines are in use, a set of men are required to go with the machines, usually three or four to each machine, and they are followed by fillers who get *down the coal which has been undercut by the machine, and fill it into tubs.*

The great advantage of coal-cutting machines in a seam which is adapted for their use, is that with the same number of men a larger quantity of coal can be got from a given face in a given time, and thus the production per man is increased.

The number of men employed in the face in coal getting constitutes, as a rule, rather less than half—40 to 50 per cent—of the total underground.

This labour is paid by the "piece," that is, by the ton of coal got, and the cost of it forms usually rather more than half, say 50 to 60 per cent, of the total cost per ton of labour underground.

2. It is in transporting the coal from the face to the surface that most of *the boys* are employed in driving horses and ponies, in coupling together the tubs to make up the "sets" at the engine-plane landings, connecting and disconnecting the haulage ropes, greasing ropes and sheaves, attending to the signals, "braking" the rope drums on self-acting inclines. Bigger lads of seventeen to twenty or thereabouts are employed as "putters" or "trammers" in "putting" or moving the loaded tubs, generally with the aid of ponies, from the coal face to the engine-plane landing, where the mechanical haulage begins. The advent of electricity and compressed air has led to the introduction of small haulage motors, which can be placed near the face, and which, to a large extent, do the work of the "putters." This is known as secondary or auxiliary haulage (Plate III.). There are a good many collieries now where the whole of the haulage from the face to the shaft is done by mechanical means, and no horses or ponies are employed.

Amongst other "transport" labour are "rolleywaymen" or roadmen, who supervise the traffic and keep the roads right during working hours, and "onsetters" or "hitchers" at the shaft bottom to take the empty tubs out of the cages, and replace them with loaded tubs.

3. As regards the labour required to make and repair

roads, this also varies very much with the natural conditions of the mine.

In deep mines there is sometimes enormous pressure on the roads. The strongest timber is broken, and every road has to be cut out of the solid strata two or three times over before it will stand, and the movement of the strata cease. This entails a large amount of labour.

The length of the roads and of the airways to be maintained also is very different at different collieries. Under average conditions about 20 to 30 per cent of the total labour underground is employed in this way, as "stonemen," "shifters," and "wastemen," as they are termed in the Northern coal-field. The "wastemen" travel the return airways, or the "waste," and are employed on the maintenance of that part of the mine. "Shifters" get their name probably from much of their work being the "shifting" of stone and timber and rails in the repairing of the roads.

Mr. Hugh Bramwell, when chairman of the South Wales Coal Owners' Association, in giving evidence before a Departmental Committee in September 1915, made the following statement of the percentage of different classes of workmen employed in a group of Welsh steam coal collieries:—

Underground Labour—	Per cent.	
Colliers (i.e., men and boys employed in getting and filling the coal at the faces	36	
Repairers (engaged mostly in afternoons and nights)	28	
Traffic men (hauliers, engine-drivers, hitchers, etc.)	18	
Officials (overmen and foremen)	2	
	—84	underground
Surface Labour—		
Traffic and screening	6	
Enginemen and stokers	2	
Mechanics	3½	
Foremen, clerks, and weighers	1½	
Sundry labourers	3	
	—16	aboveground
	100	

In South Wales where the seams are soft, and the pressure on the roads is heavy, the proportion of men employed in the face in coal-getting is generally lower, and the proportion employed on the roads, as repairers, is higher than in some other coal-fields.

To show further the division of labour employed in coal mining, the following instance may be taken.

It is a Durham colliery with a vendable output of about 5960 tons a fortnight; a comparatively small colliery.[1]

In this case the hewers or coal-getters form 56 per cent of the total employed in comparison with 36 per cent at the Welsh collieries, and the shifters and stonemen, corresponding to the "repairers" in Wales, are only 9 per cent of the whole, as against 28 per cent in the other case. The surface hands constitute 10 per cent of the total at the Durham Colliery, and 16 per cent at the Welsh collieries, as compared with just under 20 per cent for the whole country on the total figures for the year 1913. These figures illustrate the difference in the conditions of different collieries.

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[1] See evidence given by Mr. T. Y. Greener before the Eight Hours' Committee in 1907.

DETAILED STATEMENT OF ALL LABOUR EMPLOYED.

Underground.	
Hewers	240
Putters	47
Shifters	21
Stonemen	16
Drivers	11
Inclines	10
Helpers up	8
Rolleywaymen	3
Water leaders	4
Onsetters	2
Horsekeeper	1
Deputies	13
Overmen	2
Underground	378
Surface	46
Total	424

Surface.	
Winding engine	3
Hauling engine	1
Screenmen	10
Banking out	3
Labouring	3
Lampmen	3
Weighman	1
Carting	1
Railways	2
Smiths	5
Joiners	4
Masons	2
Cottage work	5
Coal washing, etc.	2
Stone teemer	1
	46

In a coal mine, as a rule, rather more than half of the total labour employed underground is engaged on "dead" work, as it may be termed, in contradistinction to the "useful" or "live" work of coal-getting in the face.

To direct and supervise all this labour, various grades of officials are employed.

Emerging from the workmen themselves, are a class designated in the Coal Mines Act, 1911, as Firemen, Examiners, and Deputies—a class on whom depends to a large extent the efficient working of a mine. Section 15 of that Act enacts that they must be the holders of certificates obtained by examination as prescribed. To each of them is assigned a certain district of the mine, including a certain number of men. Their general duties as stated in the Act are "to make such inspections and carry out such other duties as to the presence of gas, ventilation, state of roof and sides, and general safety (including the checking and recording of the number of persons under his charge) as are required by this Act and the regulations of the mine."

Besides the deputies, there are foremen or overmen in charge of different departments, e.g., the master-shifter—as he is called in the Northern district—who supervises the shifters and stonemen, who do the repairing and stonework, when the pit is not drawing coals; and the master-wasteman, who is responsible for the maintenance of the return airways.

Just as it has been said that the sergeants are the backbone of the British Army, similarly the efficiency of a colliery depends largely on the deputies and under-officials.

During each coal-drawing shift the pit is in the immediate charge of an overman or under-manager. An under-manager must be registered as the holder of a first-class or a second-class certificate of competency under the Act.

As regards the surface labour, there is an official in charge of the screening and cleaning of the coal, and filling it into trucks; and over the enginemen, masons, and mechanics is an engineer of practical experience in the mechanical side of colliery work.

At a large modern colliery there will be employed also an electrical engineer and a surveyor.

Over all is the manager, who under the Act is "responsible for the control, management, and direction of the mine," and has to exercise "daily personal supervision."

The paramount importance of a staff of loyal and capable overmen and deputies is evident. They are in constant contact with the workmen in a way that the manager cannot be. In the past they have been the pick of the mining community, capable men of character and self-respect, and of special competency in practical mining work, and distinguished, many of them, by a splendid sense of devotion to duty. Latterly there have been symptoms of dissatisfaction and unrest among them, arising very naturally from the higher wages earned by hewers and stonemen on piece-work, by the disturbing effect of recent legislation, and by the growing strength of the Miners' Union. If they are to perform their duties properly the deputies should be entirely independent of the Miners' Union. They are part of the official staff, and for the successful working of a colliery it is essential that their status should be fully maintained, and that they should receive adequate education and adequate wages.

CHAPTER III

WAGES

THERE are few other industries, if any, where the rates of wages fluctuate so much and so frequently. This is due to the violent alternations of prosperity and adversity which are a feature of the coal trade.

This perhaps accounts in some measure for the plethora of disputes which distinguish coal mining. Regular wages with regular employment is an important factor tending to industrial peace.

In considering miners' wages, it should not be overlooked that the term "miner" covers a number of different grades or classes of labour which are paid different wages.

The coal-hewers who actually get the coal are paid, rightly enough, the highest wages. They constitute at most collieries less than half of the total men employed underground, but they receive considerably more than half of the total wage fund.

A man belonging to another grade may be getting only a half or a quarter of what a hewer is paid.

And when increases are made it is by a uniform percentage rate on all wages, so that these differences are further magnified. In prosperous times when there are frequent increases, it might be more equitable if the percentage given was varied according to the varying rates of wages, so that the lower-paid men received proportionally a rather larger increase than the more highly paid.

This method of varying the percentage increase given in proportion to the existing wages has been carried ou satisfactorily in the Tinplate industry.

In the Coal-mining industry the fluctuations of wages take effect by rises or falls in the percentages paid on standard rates of wages prevailing at a particular date, which vary in each district. In the Federated Districts (comprising Yorkshire, Lancashire, Cheshire, Derbyshire, Nottinghamshire, Leicestershire, Shropshire, part of Staffordshire, Warwickshire, and North Wales), and in Scotland, this date is 1888; in Northumberland and Durham, November 1879; and in South Wales and Monmouthshire, December 1879.

The following figures are the percentages upon these standard rates paid in each district at the end of the years 1896, 1906, 1910, and 1913.

		Percentages paid on Standard Rates at End of each Year.				War-time.
		1896	1906	1910	1913	1916
Above Standards of 1879.	Northumberland	3¾	23¾	31¼	52½	120
	Durham	15	32½	43¾	60	107½
	Cumberland	30	37½	47½	65	
	South Wales and Monmouth	10	37½	51¼	60	133¾
Above Standards of 1888.	Federated Districts	30	40	50	65	110⅔
	South Staffordshire and East Worcestershire	30	..	50	65	
	Forest of Dean	15	30	35	40	
	Bristol	17½ & 22½	...	40 & 45	55 & 60	
	Somersetshire (Radstock District)	15	30	40	55	
	Fife and Clackmannan	at standard	43¾	50	87½	
	West Scotland	12½	43¾	50		150

These figures show the large increase that has taken place in miners' wages during the seventeen years 1896–1913 and during the three years preceding the war, 1910 to 1913.

In place of advances by percentages on standard rates, a new method was introduced by the Coal Controller, when at September 17, 1917, a special advance was given "in the shape of a war wage of 1s. 6d. per day to be paid to all colliery workers (male and female), including apprentices of 16 years of age and over, and 9d. a day to those under 16 years."

A further innovation of a far-reaching and objectionable character—of pay without work—was also introduced in making this wage payable, even when the worker does no work, so long as he is ready to work.

"The special advance will be paid for every day on which a worker works, and for every day on which a worker is ready and able to work, but is prevented owing to the work of the pit seam, or place, being stopped by causes other than strikes, excluding recognized holidays, Sundays, stop-days, etc., but including days on which the work of the pit seam, or place, is temporarily stopped through lack of trade."

The immediate result of this edict was that at many collieries, the number of minimum wage men was largely increased. A number of men who had been earning above the minimum wage level now relaxed their efforts, being content with less work and the increased minimum wage thus given them. Thus the output was reduced at a time when in the national interests more coal was urgently needed.

Wages should be arranged, so far as possible, not to take away incentive to effort, but to encourage and reward better work.

Independently of the large increases in the percentages paid on standard rates as shown above, the wage rates of many classes of miners have been considerably raised under the Minimum Wage Act, 1912.

No rates are laid down in this Act, but it was left to the Joint District Boards constituted by the Act to settle minimum rates, having regard to the average daily rate of wages paid to each class of workmen.

Twenty-two Joint District Boards were formed under this Act, and the settlements made by the different Boards show considerable variation. In nearly all districts the boys of fourteen years of age got the 2s. a shift, which was the minimum rate asked for them, with annual increases on this, as they grow up to manhood. In South Wales the men were classified into thirty classes, and the minimum rates fixed for twenty-one out of the thirty classes range from 5s. to 6s. 10½d. In Northumberland one uniform minimum of 4s. 9d. was fixed for all day-wage men. And this rate—4s. 9d.—was about the average rate fixed in all the other districts for day-wage men. For piece-workers, the average minimum rate throughout the country was 6s. This *minimum* rate is of course considerably below the *average* earnings of coal-getters paid by the piece.

The total increase in miners' wages under this Minimum Wage Act has been variously estimated to be from £1,000,000 to £2,000,000 a year.

In County Durham and in Northumberland there is always a recognized county average rate of hewers' earnings, varying in amount from time to time according to the rise and fall of the percentage rate in force. When the hewers' average earnings at any colliery or district of a colliery are at least 5 per cent above or below this recognized county average, a readjustment of the prices paid for hewing may be obtained. The hardness of coal seams and the difficulty of hewing them varies a great deal. In some seams a man will be able to get 6 tons of coal in his shift, and in another not more than two tons, and the rates paid per ton have to be fixed accordingly.

The hewers' county average rate of earnings in County Durham at the end of 1913 was 7s. 2d. a shift of seven hours, reckoned from the time of leaving the surface to the time of returning to it, and the actual average rate of earnings is at least 5 per cent above this. And besides this, all married hewers in Durham and Northumberland are allowed house and fire coal free, the value of which is taken generally to be 9d. or 1s. a shift.

Thus coal hewers in County Durham were earning on an average about 8s. a shift of seven hours' work during 1913 when the percentage rate was 60 per cent. Working full time, or eleven days a fortnight, a hewer would earn in the fortnight £4. 8s., or £2. 4s. a week, on the average, some of course making more than this. Working full time his hours of work are seventy-seven hours in the fortnight. Thus his working hours amount to 23 per cent of the total hours in a fortnight, and for 77 per cent of his time he is free to do what he likes.

The rise in wages during the ten or twenty years preceding the war was greater in coal mining than in any other important industry.

In comparison with some other industries, coal miners also have an advantage in being able to get good employment for their sons as soon as they reach fourteen years of age. Many miners' families, where there is more than one worker, have been earning during recent years before the war £3 to £5 a week. It is the wage of the family rather than of the individual that should be considered in connection with the well-being of the whole community. In some parts of south-east France, wages vary with the size of the worker's family. (See Mr. Ernest Barker's Letter in *Times* of August 22, 1918.)

Some figures of the actual earnings of coal miners may be of interest. At the annual meeting, held in March 1915, of the Consolidated Cambrian Limited, one of the largest and most successful of colliery companies, employing 12,930 workmen, the chairman, Mr. D. A. Thomas (afterwards Lord Rhondda), stated that the average wages of colliers (i.e., coal hewers) had been during 1914 55s. 6d. per week, and the average wages of all persons, including boys, above and below ground, had been 42s. 6d. per week. For every 1s. received by the ordinary shareholder, the workman was paid about 14s.

The amount paid in wages during 1914, namely £1,219,312, was a little over 71 per cent of the total cost of production, not including the salaries of the clerical staff.

For their enterprise, which provided the means of subsistence for some fifty or sixty thousand people, Cambrian ordinary shareholders in the aggregate received annually less than 7½ per cent of the amount they paid in wages.

During the following year, 1915, wages were still higher.

During the fifteen weeks ended December 31, 1915, the average earnings per day of all the colliers employed by this Company were 11s. 8·03d. Over 12 per cent of the men employed earned more than 15s. per day.

Of the total cost of production during the year 1915—

Labour cost	75·49 per cent
Stores and materials cost	18·23 ,,
Royalties cost	3·22 ,,
Rates cost	2·22 ,,
Incidentals cost	0·84 ,,
	100·00 per cent.

During 1915 a great many miners were earning at the rate of more than £200 a year.

In June 1918, a statement was issued by the Monmouthshire and South Wales Coalowners' Association showing the current *minimum* wages paid to underground day-wage men, including thirty-six different classes of workmen, for a week of six days' work at July 1914 and June 1918. These *minimum* weekly wages at June 1918 ranged from 55s. 9d. to 72s. 8d., and the increase compared with July 1914 ranged from 23s. 10d. to 36s. 4d., or from 67 to 107 per cent increase, according to the class of labour.

This rise in the minimum weekly wages of underground day-wage workmen in South Wales is shown graphically in the accompanying diagram, which is taken from the *Colliery Guardian* of January 24, 1919. It does not include the wages of miners engaged in the work of hewing the coal, who are the most highly paid.

During this period—1914–18—the increase in the cost of living of working-class families—taking into account food, rent, clothing, fuel, insurance, household sundries, and fares—was on the general average 70 per cent. (See

Report of Exchequer Committee, November 1918—Parliamentary Paper, Cd. 8980.)

The British coal miner is one of the best paid workmen in the world, and long may he continue to be so.

REGULATION OF WAGES

The rise and fall in the percentage paid on standard rates is ruled mainly by the rise and fall in the selling price of coal, the state and prospects of the trade being also taken into account. Latterly there has been a movement in some districts to take into consideration also the cost of production. Sliding scales between the rate of wages and the selling price have been in force from

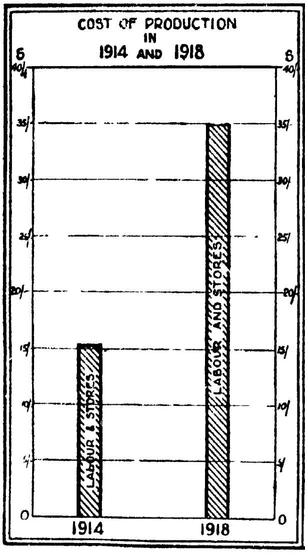

Table showing the average cost of production per ton of large coal at the pit in 1914 and 1918.

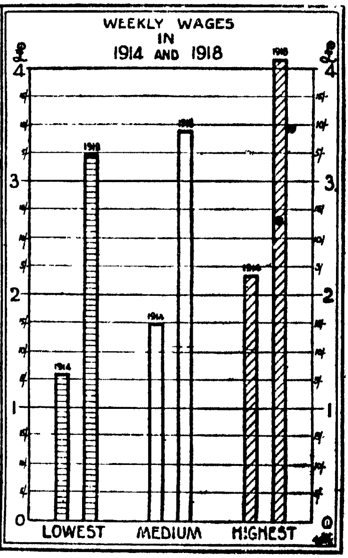

Table showing the weekly minimum wage of the lowest, medium, and highest paid underground day-wage workmen in 1914 and 1918.

time to time, but have been generally terminated by the workmen.

In Northumberland at present a sliding scale is in force. Under it, wages rise and fall by 1 per cent for each penny change in the selling price. But when the selling price falls below 7s. 5d., wages are not further reduced.

At this selling price wages are 25 per cent above the basis of 1879. This establishes a minimum wage rate for hewers of 25 per cent above 5s. 2d. a shift, or about 6s. 5d. a shift. Similarly, at the other end of the scale, the maximum is fixed at 65 per cent, which corresponds to a selling price of 10s. 8d. per ton. If the selling price rises above 10s. 8d., the wage rate remains at 65 per cent above the basis of 1879.[1]

Ascertainments of the selling price are made every three months.

In County Durham the wages were regulated by an agreed sliding scale for twelve years from 1877 to 1889. Twopence in the selling price corresponded to 1¼ per cent in wages, rise or fall. The difficulty lies in agreeing on the minimum or lower end of the scale, at which reduction of wages is to stop, and on the base relationship between selling price and wages. In the Durham and Northumberland sliding scales, the selling price is got by dividing the total money received for coal at the pit's mouth by the total output on which wages are paid. In South Wales, it is the average price of screened coal "free on board" at the nearest port, and an ascertainment is made every two months.

In South Wales, where the late Lord Merthyr was a strong advocate of the principle of the sliding scale, wages were thus arranged from 1875 to 1902. During this period of twenty-seven years, five sliding scale agreements were successively in force. The last was arranged in 1892 and lasted till 1902. Under it 1¼ per cent rise or fall in wages above standard rates was given for every 1·71d. per ton change in the selling price. This ratio is equivalent to 8¾ per cent on the shilling. Under this scale the percentage above standard rose to 78¾ in April 1901. This was the highest reached, and the lowest was 10 per cent, which was touched in June 1893, and again in October and in December 1896 and in February 1897—evidence of how much the prosperity of the industry may vary within a few years.

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[1] These terms were modified during the period of the war.

In 1902 a new agreement was made—Sir David Dale acting as arbitrator—under which 11s. 10d. was fixed upon as the equivalent selling price of a minimum wage rate of 30 per cent on the standard rates of 1879. In 1910 this was raised to an equivalent selling price of 12s. 5d. and a minimum of 35 per cent on standard rates.

The exigencies of war-time have been pressed to the utmost by the South Wales miners to obtain better terms for themselves, and in December 1915 they put forward the contention that the question of an equivalent should be discussed each time a change in the general wage rate is under discussion, a contention which knocked the bottom out of the existing agreement, and caused the resignation of the independent chairman of the Conciliation Board.

The regulation of wages remained in a state of chaos, owing mainly to Government interference, until December 1, 1916, when, a strike being imminent, the Board of Trade, acting under the Defence of the Realm Act, took possession of all the coal mines in South Wales and Monmouthshire.

Three months later another order was made, taking possession from March 1, 1917, of all the coal mines in the United Kingdom. A Board of Control was appointed, with the late Mr. Guy Calthrop, the general manager of the London & North-Western Railway Company, as Controller, and an Advisory Board, consisting of five representatives of coal owners, and five representatives of coal miners in the various mining districts, was attached to the Board of Control.

The steady rise in wages which has been general during many years before the war is indicated by the alterations in the ratio between wages and selling prices in these sliding scales.

At November 1887 the agreed ratio in South Wales was 1¼ per cent in wages to 2d. in selling price, which is the same as under the last Durham scale. This was altered in 1892 to 1¼ per cent for each 1·71d. per ton change in the selling price, and the present Northumberland scale gives 1 per cent in wages for each 1d. per ton change in selling price.

Little by little during the thirty years before the war the proportion between selling price and wages has been changing in favour of wages, till now it runs about 5 : 3. Out of every £1 received, not less than 12s. goes in wages. In other words, the coal miner gets 60 to 70 per cent of the selling price.

Mr. Arthur Pease has stated that for the ten years 1904–1913 the profits divided among the shareholders of his firm, Messrs. Pease & Partners Limited, who work extensive collieries in County Durham, were only about 6 per cent of the selling price, whilst during the same period wages and salaries absorbed 64·04 per cent. (See Lecture on "Coal Trade Problems," London School of Economics, October 19, 1917.)

It was stated in an address given on June 26, 1915, to the members of the Midland Branch of the National Association of Colliery Managers by Captain P. Muschamp, the president, that, "At the present time, out of every sovereign received from the sale of coal, about 13s. 8d. was paid away in wages, workmen's coal, compensation, and insurance."

Is there any other important industry in which the manual worker receives so large a share of the total product?

The regulation of miners' wages by the selling price of coal, as a method recognized by both employers and workmen, has served a useful purpose in preventing disputes and strikes, but it has a serious drawback in its tendency to limit the output of the miner, because an increased supply tends to lower the selling price. It is mainly with the object of securing a high rate of wages that the miners' Unions have adopted the deliberate policy of restricting output.

How does this affect the individual coal miner? So long as he has regular employment at a high rate of wages, so long, that is to say, as all the coal raised can be sold at a profit, the policy of restriction from the point of view of his individual interest appears to be justified.

But the miners overlook the fact that by restricting their output they increase the cost of fixed or standing charges and thus reduce the fund out of which wages are paid. Machinery must be maintained, water must be pumped, horses must be fed, rates and taxes and rent and salaries must be paid, whether the output goes up or down, and the cost per ton of these fixed charges varies inversely with the output. If it goes down, they go up, and there is less money for wages.

From the point of view of the consumer—and almost everybody is a consumer of coal—a high price artificially maintained by restriction of output has nothing to recommend it.

It is essential to increased production that greater effort of the worker should lead, not to reduced wages, but to greater reward.

It has been suggested that a better regulator of wages than the selling price would be the difference between the selling price and the cost of production. This would encourage increased production, because a larger output lowers the cost of production, and would be followed by a higher rate of wages.

The late Mr. J. H. Merivale, who did so much good work for the coal-mining industry, was for long an advocate of this change in the Northumberland coal trade. The men are not averse to trying experiments of this kind, but the war has prevented developments.

Probably in future miners' wages will be regulated with reference to the profit made instead of the selling price.

COST OF LIVING

In considering wages it should not be forgotten that their value is relative to the cost of living. Food and clothing, house and firing, are the essential items in the cost of living, and the prices of these things—that is, their exchange value in gold—varies a good deal from time to time.

As the available supply of exchangeable gold increases relatively to other commodities, the prices of these commodities tend to rise. The more money there is in circulation the higher are prices likely to be. The high prices that prevail now are due largely to the inflated currency arising from the issue of paper money during the war.

During the quarter century succeeding the year 1873, after the Franco-German War, the general tendency was towards falling prices, and an increased value of money. During the first thirteen years of the present century the tendency has been the other way, towards an increase in the quantity of available gold, and a rise in prices.

This is well shown by Sir George Paish in a paper on the Prices of Commodities in 1913, published in the *Journal of the Royal Statistical Society* for April 1914. This paper is a continuation of the well-known work of Mr. Augustus Sauerbeck. Forty-five commodities are taken, nineteen of them being articles of food, such as beef, mutton, pork, bacon, butter, flour, potatoes, rice, wheat, barley, sugar, tea and coffee, etc.; seven of them minerals, coal, iron, copper, tin, etc.; eight of them textiles, cotton, silk, wool, hemp, etc.; and eleven of them sundry materials, timber, hides, leather, oil, etc.

The prices of these commodities are ascertained and a general average drawn for each year, the figure obtained being the simple arithmetical mean of the whole of them.

If the prices of any selected year, or period of years, is represented by the figure 100, then the relative prices of any other year or period may be expressed by the figure of its ratio to 100. Thus the rise or fall of prices over a series of years is readily shown.

The standard period selected by Mr. Sauerbeck is the decade 1867–77, and it has been shown that in the aggregate the prices of this period are equivalent to the average of the twenty-five years 1853 to 1877.

Taking 100 to represent these prices, that is, the cost of living during the third quarter of last century, it fell to 66 at the end of the century. This is the lowest on record, and is the figure for the last decade of the nineteenth century, namely, 1890–99. This lowest figure continued to the decade 1894–1903.

It appears to be established that there is a periodical fluctuation of prices between a highest point and a lowest every nine or ten years. Therefore in order to obliterate these ordinary fluctuations, and to give the best picture of the general movement of prices, Sir George Paish, in the paper referred to, gives the index numbers for whole decades commencing with each year since 1877.

After 1894–1903, a steady rise set in, reaching 73 in the first decade of the present century, and 77 in the ten years 1904–1913. This is an increase of 16½ per cent above the figure (66) for the period 1890–99, which is the lowest on record, but it is much below the prices of the standard period 1868–77.

It is interesting to note that the production of gold rose considerably during the first eleven years of the present century, and has since been falling. In 1911 the estimated production was £97,300,000, in 1912 £97,000,000, and in 1913 £94,700,000.

In a debate on February 11 and 12, 1915, in the House of Commons on the cost of living, the Prime Minister stated that though the prices of the chief necessaries of life had risen much during the first six months of the war, yet they were not so high as the prices which prevailed during the years 1875–85, succeeding the Franco-Prussian War. "Wages were not so high then as they are now. Money wages were certainly from 15 to 20 per cent lower in those years, and common articles of food were as dear throughout those years as they have become with the recent marked advance. The average weekly price of flour in this year 1915 is not higher than the price which prevailed in most of the years 1875 to 1885."

It is the general standard of living that has risen. People want more than they did.

It is estimated (see *Labour Gazette* of May 1919) from such information as is available, that the average increase of miners' wages during the war is probably equivalent to about 110 to 120 per cent on the pre-war average wages of all classes of workers in coal mines.

The increase has more than counter-balanced the increased cost of living, and house and firing, those important items, are supplied to coal miners on specially easy terms.

As Lord D'Abernon pointed out in his evidence before the Coal Commission, it is desirable that there should be some sliding scale or system of automatic adjustment between wages and the cost of living.

It is satisfactory to know that on the whole the poorer classes are better off at the end of the war than they were before it. (See Report issued November 1918, Parliamentary Paper (Cd. 8980) of Committee appointed by Chancellor of the Exchequer—Chairman, Lord Sumner.)

Evidences of this are the remarkable decline in pauperism, which at the end of the war was very much lower than it has ever been before, and in the better feeding of the children.

Only in very exceptional cases were the education authorities supplying anything like as many meals to children as before the war.

CHAPTER IV

DISPUTES AND METHODS OF SETTLING THEM

OF all hand-workers, the coal miners are the most exorbitant and unceasing in their demands.

"The miner is the doughtiest fighter in the industrial field."

According to statistics of disputes causing strikes or interruption of work, published by the Board of Trade, 21·4 per cent (on the average) of workpeople engaged in coal mining were involved in disputes during the decade 1904–1913. Next to them come the Textile industry with only 6·4 per cent, the mean percentage during this decade in all the groups of trades being 4·4 per cent.

In 1913 there were 163 disputes, involving 148,567 workpeople, in the coal-mining industry alone. Most of these disputes, it should be said, affect a comparatively small number of workmen, and the stoppage of work lasts for only a short time, usually not more than a week. Some of them too are entered upon and continued by the men against the advice and desire of their Union officials.

It must be admitted that coal miners are sometimes arbitrary and unreasonable in their methods and demands. For instance, at a colliery in South Wales where deductions from wages were made by the employers for the payment of doctors under a long-standing arrangement, the miners demanded that deductions should be made also for other doctors appointed under a new scheme adopted by some of the men, and because this demand was not granted, about 5000 miners struck work for some days! Similar instances might be quoted from other districts.

At almost every colliery there is a Trade Union official chosen and paid by the men to look after their interests. Sometimes, unfortunately, he degenerates into a paid agitator whose chief occupation and interest it is to provide a constant stream of demands and disputes. If there were no disputes, his occupation would be gone.

The new unionism aims at getting more control of industry. Half the disputes in coal mining are not about wages or hours of work, but about matters of discipline, and working arrangements, and the employment of certain persons.

In all the mining districts there are strong associations of employers as well as of workmen, and questions affecting the industry are discussed at meetings of the representatives of both Associations. In this way by direct negotiation disputes may be settled and agreements made.

There is besides in most districts special machinery for settling disputes in the shape of Conciliation Boards and Standing Joint Committees. These Boards and Committees are quite independent of the new District Boards appointed under the Minimum Wage Act.

The chief function and value of Conciliation Boards is to bring together the two parties, and give them the opportunity of discussing any matter in dispute in an amicable manner.

With the appointment of an independent chairman or umpire, whose decision both parties agree to accept, and with goodwill on either side, these Boards may be made the means of settling most questions that arise.

But at present they have no power of enforcing their decision, if either party breaks it.

This has occurred more than once, particularly in the proceedings that led up to the national coal miners' strike of 1912.

It is obvious that loyalty to chosen representatives and the strict observance of agreements made by them, on the part of both employers and employed, are essential to the successful continuance of collective bargaining between them. The turmoil which results from a breach of agreement between the contracting parties, is well exemplified by experience in the South Wales coal-field, and unfortunately the breach of contract was due to the interference of the Government.

By its action in South Wales, the Government has directly encouraged working-men to break their contracts with their employers. It has been stated on good authority that the chief cause of trouble in the South Wales coal-field has been the action of the Government in assisting men to break their agreements.

It has been proposed and it is advocated by men of experience in industrial affairs that either party—employers or workmen—should be made legally liable to pecuniary penalties in case of breach of decision.

The "British Workers' League"—an important body representing some of the best elements of Labour—in their programme for reconstruction after the war (October 1917), has declared in favour of legal enforcements of industrial agreements. But it is the spirit of conciliation and goodwill which is the vital factor in the settlement of all industrial disputes.

In respect of Conciliation Boards and Standing Joint Committees, Northumberland and Durham have been pioneers.

The Commissioners appointed by the Government (July 1917) to inquire into the causes of industrial unrest pay a high tribute to the effectiveness of the organization for dealing with disputes in the Newcastle coal-field. In their report for the North-East coast district they state that: "The result of our investigation has been that, speaking generally, there is no unrest in the mining community. There exists an arrangement between employers and employees which for a long period of years has secured amicable settlements of contentious questions, and we can suggest no method of dealing with disputes which is likely to meet with more success in this very important field."

Durham may be taken as a good example of what has been done for the amicable settlement of the many matters in dispute which are constantly arising in the coal-mining industry and in the management of collieries.

The Durham Coal Owners' Association was formed in 1872, and embraces 95 per cent of the colliery owners of the county. A Conciliation Board was constituted in 1895, but lasted only for a year or two, being terminated by the men. It was, however, re-formed in 1899, and is still in existence, having stood the test of twenty years.

It may be terminated by six months' notice by either side, and this probably tends to its continued existence. It is composed of eighteen members of the Owners' Association and eighteen of the Miners, Cokemen, Enginemen and Mechanics' Associations.

Its powers are wide, covering any matters in dispute respecting work and wages.

There is an umpire—at present Sir David Harrel—and the vice-chairman is Mr. W. B. Charlton, the secretary of the Enginemen's Association.

Agreement may be come to by a general discussion at a meeting of the Board, or a matter may be referred to a special committee for further consideration and report. Failing decision otherwise, a meeting is held with the umpire present as chairman. His decision is accepted as final. The principle of compulsory arbitration in some form or other is accepted by all the Conciliation Boards in the coal trade of the United Kingdom, with the exception of the Forest of Dean. In this connection it may be noted that the Whitley Committee in a report (issued in June 1918) on conciliation and arbitration pronounced definitely against compulsory arbitration. On the question of arbitration, the Committee in their final report (September 1918) say: "Relying in the main on the methods built up by agreement within the various industries, and looking to an expansion and improvement of these methods resulting from the habit of dealing with common questions in Joint Council, we have limited our new proposals to the establishment of a small Standing Arbitration Council, on the lines of the present Committee on production, to deal with cases where the parties have failed to come to an agreement under their ordinary procedure and wish to refer their differences to this Council."

The Committee on Production as reconstructed and enlarged in May 1917 is an arbitration court, to which cases are referred when the parties have failed to agree. "It consists of 12 members, divided into four panels of 3, each panel containing a representative of the Government, the employers, and the trade unions; and this division of labour enables it to deal promptly with a very large number of cases. During the last five months the average number of awards given was about 240 a month. The panel system enables it to hear cases locally as well as in London; the panels are in fact travelling courts." (See *Times*, October 11, 1918. Letter by "Conscius.")

But machinery, it should be remembered, is useless without proper driving power, and organization to be of value must be animated by the right spirit.

It is to the credit of the Durham Conciliation Board, which controls the wages of about 125,000 workmen, that during its existence, lasting now for twenty years, with the exception of the National Strike in 1912, when conciliation boards and existing agreements were ignored, there has been no general strike in County Durham. The passing of the Eight Hours' Act caused a great upheaval in 1910, and about one-third of the Durham miners were on strike for some time against the agreement come to by their representatives, but eventually the original settlement was enforced.

The success of Conciliation Boards and of similar machinery depends on the men composing them, and especially on the leaders on either side.

To the late John Wilson, M.P., the secretary of the Durham Miners' Union for so many years, is largely due the success of the Durham Conciliation Board. Testimony to this effect has been borne—amongst others—by Mr. W. B. Charlton, secretary of the Durham County Colliery Enginemen's, Boilerminders', and Firemen's Association, who has stated that, "The Board carried within itself more of the best that John Wilson could give than any other formation I know of, and through its functions John Wilson has done more for the people he represented than can ever be tabulated."

Mr. Charlton has stated also that, "As a charter of rights to mine workers, the Conciliation Board in this county is unequalled."

Another Conciliation Board which has had a successful career is that of the Federated District, which covers a wide area and regulates the wages of more than 300,000 men. It was formed at the end of the year 1893 after a sixteen weeks' strike, and has maintained its existence ever since, with the satisfactory result that there have been no strikes in this area, with the exception of the National Strike in 1912.

Reviewing its work, it is interesting to note that during the twenty years—1894 to 1914—advances in wages have been given on fourteen separate occasions, the amount of the advance being 5 per cent on the basis wages on every occasion except two, when it was 2½ per cent; and during the same period, reductions have been made on five occasions, the amount of reduction being also 5 per cent, except in July 1902 when it was 10 per cent. The total advances have amounted to 65 per cent, and the total reductions to 30 per cent.

But the most interesting point to note is the advance that has been made by mutual consent in the various agreements made by the Board in the minimum and maximum points of the wage scale.

At the first formation of the Board in 1893, the limiting points to the fluctuation of wages were fixed at 30 per cent on the basis wages of 1888 as a minimum, and 45 per cent as a maximum. This minimum of 30 per cent was advanced to 35 per cent in 1904, 37½ per cent in 1907, and to 50 per cent in January 1913; and the maximum of 45 per cent was raised to 60 per cent in 1901, and to 65 per cent in January 1913.

On May 1, 1915, a new agreement came into force for three years under which the standard of 1888 has been abolished, and an increase of 50 per cent on the 1888 standard has been established as the new basis. Under this new agreement the limiting points of the fluctuation of wages are 65 per cent above the 1888 standard as a minimum, and 85 per cent as a maximum.

This is an instructive example of the course of miners' wages as arranged by mutual consent between them and their employers during the twenty years preceding the war.

JOINT COMMITTEES

For settling local disputes at any particular colliery between the management and workmen in County Durham, there are Standing Joint Committees—seven of them—consisting of six representatives of either side, with an independent chairman. For the miners' cases, the county is divided into three districts with a Committee for each district, and there are also Committees for the enginemen, for the mechanics, for the cokemen, and for the deputies—seven Standing Joint Committees in all. During 1913 these Committees dealt with 901 cases, of which 836 were miners' cases, forty-five cokemen's, six enginemen's, and fourteen colliery mechanics'. Four hundred and sixty-two of these cases, or 51 per cent, were withdrawn, ruled out of order, or settled independently of the Committee; 257, or 29 per cent of them, were settled by conciliation; and 182, 20 per cent by arbitration. Failing agreement by conciliation, at a meeting of the Committee, the matter in dispute is referred to two referees on either side, who have no connection with the case, and if they cannot come to an agreement, an umpire is called in, and the question is thus settled by arbitration.

That half the cases brought are withdrawn or ruled out of order or settled independently of the Committee, suggests that these facilities for settling disputes create disputes! Certainly many of the cases ought never to have been brought. Cases are sometimes put on the agenda paper of the Joint Committee before any effort has been made to settle them at home. In the Cleveland ironstone district, where a similar organization exists, there is a useful rule that no case will be heard unless an effort has been made previously to settle it by a meeting of the management and the representatives of the workmen of the mine.

There are unfortunately a great many instances in Durham where the award of the Committee has not been accepted or kept. To counteract this, it is a rule, which no doubt has a good effect, that no cases will be heard from a colliery which is not complying with a previous decision.

Useful information about Boards of Conciliation in the Coal Trade is given in a paper on "The Working of Conciliation Boards in the Coal Trade, with Special Reference to Scotland," read before the Royal Philosophical Society (1915), by Sir Adam Nimmo, M.A., the chairman of the Conciliation Board for the Coal Trade of Scotland. It is pointed out that their success much depends on the rules and regulations defining the questions that may be considered, and on the facts and considerations that may be taken into account in arriving at a decision.

In conjunction with most of the Conciliation Boards in the coal trade, there are Wages Agreements, which answer this purpose by laying down the area of mutual consent, and limiting, as far as possible, the area of probable friction.

Sir A. Nimmo points out that Conciliation Boards cannot solve the fundamental question between employers and workmen, namely, what is a fair wage for the one and an adequate profit for the other. They assist the workman more than they do the employer. They are used as a lever to raise the position of labour, and this irrespective of the economic ability of the average employer and the broad interests of the industry. The employer is practically always on the defensive, and the workman practically always on the offensive. But they have had an educative influence on both employers and workmen, and have brought about a better understanding between them.

Much of the ill-will, which Labour shows towards Capital, is due to the quite mistaken notion of the profits which Capital receives, and to the silly delusion that wealth is produced by hand labour alone. The workman thinks that he is being robbed by the capitalist, and so long as this feeling of injustice exists, there can be no cordial co-operation between the two. The path of progress points to the admission of the workman to a fuller knowledge of the financial position of the enterprise in which he is engaged.

"Disputes very often arise from an exaggerated view of the return on capital invested in industry generally, and if some means can be devised by which this can be fairly accurately gauged, it would often prevent unreasonable demands being made by workpeople, or the refusals on the part of employers to share in prosperity." (Sir Charles Macara at British Association Meeting at Manchester in September 1915.)

Certainly much of the discontent amongst hand workers is due to the thought that other classes are prospering unduly at their expense. Suspicion and distrust are the twin sisters of ignorance. As Bacon puts it in his essay on "Suspicion": "There is nothing makes a man suspect much, more than to know little." And the ignorance, unfortunately, is not confined to one side. The average employer is as ignorant of the workman, of his thoughts and feelings and circumstances, as the average workman is of the employer.

There is much to be said in favour of the principle of co-partnership, or of profit-sharing, which is strongly advocated by many men of sound judgment and wide experience. But it must be acknowledged that as yet owing chiefly to its incompatibility with Trade Union ideas, profit-sharing has not made much progress in the United Kingdom. Co-partnership certainly appears to offer solid advantages to workmen, and it is not easy to understand why Trade Unionism should be so opposed to it, unless it be that the interests of the Trade Union oligarchy are put before the interests of the whole body of workpeople! According to a report of the Board of Trade, there were, on June 30, 1915, 153 firms having some form of profit-sharing in operation in their business, employing 141,112 persons. Three firms had abandoned profit-sharing during the year. They are principally gas companies that have adopted it, and with some of them it has been a great success, but they are different from other industries, in that the price they charge for gas and their dividends are regulated by Act of Parliament.

The South Metropolitan Gas Co. is the oft-quoted example of the successful working of co-partnership. The scheme was inaugurated by the late Sir George Livesey, and has been in force for about thirty years with most satisfactory results. They have a standard price of gas of 3s. 1d. per 1000 cubic feet, and at this price a standard dividend of 4 per cent on capital. For every penny reduction in the price of gas the shareholders get 2s. 8d. per cent more dividend, and at the same time the labour co-partners get 3s. 4d. per cent on their wages. Thus, in 1912, when the price of gas was 2s. 2d. per 1000 cubic feet, the shareholders received £5. 9s. 4d. per cent dividend, and the labour co-partners 5 per cent on their wages. About £750,000 has been paid to the labour co-partners, and the employees hold over £380,000 of the company's ordinary stock.

Dr. Charles Carpenter has testified to the excellent results of this scheme of co-partnership, both in increased output and in the attitude and conduct of the men employed. (See Annual Meeting of the Society of Chemical Industry in Bristol, on June 17, 1918.)

If industrial concerns regularly made good profits, profit-sharing would be more feasible. But when losses have to be faced, the workman who has all his eggs in one basket is in a worse position than the shareholder, who seldom puts all his money into one company.[1]

To be thoroughly successful an industry should command the active and intelligent co-operation of the mass of those engaged in it.

It would be a good thing if organized labour would embark on colliery enterprise on its own account, and there is nothing to prevent it.

Through their Trade Unions and co-operative associations ample funds are available for the purpose.

It has been tried on a small scale both in England and in other of the British Dominions, but so far without much success.

Probably the failures are mainly due to there being too many masters, leading to bad management and want of discipline.

A recent (1917) undertaking of this kind is the acquisition by the Co-operative Wholesale Society of the Shilbottle Colliery, a small colliery near Alnwick in Northumberland at a price, it is said, of £50,000. It is to be hoped tha the enterprise will prove successful.

It is very desirable that coal miners should learn by experience the difficulties and uncertainties that attend their industry on its commercial side.

The great danger that attends the extension of labour-control in industrial undertakings is inefficiency of management and administration. A dual control is fatal to efficiency. Personal initiative and enterprise are required for success.

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[1] A scheme of profit sharing for the coal-mining industry was proposed on behalf of the Mining Association of Great Britain by Lord Gainford before the Coal Commission.

CHAPTER V

TRADE UNIONISM

COAL miners are strongly organized in Trade Unions. The general strike of 1912 is conclusive evidence of it. As long ago as 1841 there was formed a Miners' Association of Great Britain and Ireland, and almost every year since then there has been held a national conference of miners, though it is only within recent years that it has been representative of the large majority of them. At the annual conference of the Miners' Federation held at Glasgow in July 1917, there were present 175 delegates representing 750,000 members.

At the end of the year 1913 there were 81 Trade Unions connected with coal mining, with a total membership of 885,734. This is 84 per cent of the men (over sixteen years of age) employed at mines coming under the Coal Mines Act during the same year, underground and above ground.[1]

The membership increased rapidly during the three years 1910–1913, largely owing no doubt to the general strike in 1912.

The increase in these three years was 177,694, or 25 per cent of the total membership in 1910. For the previous three years, 1907–1910, the increase in membership was only 3·6 per cent. The increase in membership of Trade Unions generally—not only of those connected with coal mining—during the year 1913 was remarkable, far exceeding any previously recorded in the history of registered Trade Unions.

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[1] At the end of 1917 there were 85 Unions of coal miners with a total membership of 918,737. This was an increase of 7·9 per cent on the membership at the end of 1916 (Department of Labour Statistics).

One of the most prevalent causes of dispute and of sectional strikes in coal mining during recent years has been the refusal of unionists to work with non-unionists, with the view of thus compelling them to join the Union.

This question was the cause of so many stoppages in South Wales, that, during the war, in April 1916, in order to prevent loss of output, the South Wales Coalowners' Association, acting under instructions from Sir George Askwith, the Chief Industrial Commissioner, agreed with the South Wales Miners' Federation that "the workmen employed at the collieries shall be *required* to become members of one or other of the recognized Trade Unions."

It may be doubted whether these methods of coercion conduce to the real strength of Trade Unions.

As at present constituted it is an open question whether they do not sometimes represent the views of a few of the more active and ardent spirits who push themselves to the front rather than the real desires of the majority of their members.

The resolutions passed at conferences of delegates have sometimes been reversed by a subsequent ballot vote of those whom they represent. The meetings of the local lodges at which these delegates are elected are attended, as a rule, by only a small proportion of the members.

Some remarks of Dr. Arthur Shadwell about Trade Unions generally are applicable to the Miners' Unions. "The great bulk of the members take no part in the affairs of their Union. They do not attend meetings, or even take the trouble to vote when a ballot is taken. Many cordially hate the whole thing; most are indifferent. Naturally the conduct of affairs falls into the hands of those who do take an interest in it, and among them the young men, better educated, better equipped for discussion, keen, voluble, primed with theories and arguments, gain the sway."

The meetings of the local lodges of the Miners' Union are seldom attended by more than the officials of the lodge or those who are paid for attending.

A few figures showing the financial position of Miners' Unions, and how the money is spent, may be of interest.

For the year 1910, the total income of sixteen of their principal Unions, having a membership representing 55 per cent of the whole body of miners, amounted to £462,146, or £1. 3s. 1d. per member; the total expenditure to £479,291, or £1. 3s. 11¼d. per member; and the funds at the end of the year were £1,637,284, or £4. 1s. 9½d. per member.

During the years 1908–10, the total expenditure of these sixteen Unions was divided as follows:—

	Percentage of Total Expenditure.
Dispute benefit	23·3
Sick and accident	21·1
Unemployed	20·2
Funeral, benevolent, etc.	12·9
Superannuation	1·2
Working and miscellaneous expenses	21·3 = 100·0

It is noteworthy that 43·5 per cent of the total expenditure went on Dispute and Unemployment Benefit, most of which was wasted on fighting the employers.

There are in some districts Miners' Permanent Relief Societies, which provide benefits for sickness and accidents, independently of their Trade Unions.

In 1913 Miners' Permanent Relief Societies contained 337,152 members and had a total revenue of £332,372. The Northumberland and Durham Society is much the largest, containing, in 1913, 209,589 members, with a revenue of £222,957.

The accumulated funds of Miners' Permanent Relief Societies in 1913 amounted to £930,932. (See Report of Central Association of Miners' Permanent Relief Societies —June 1916.)

Owing to the war, the following years show a falling off on these figures for 1913.

There is a Miners' Federation of Great Britain which includes all the principal Trade Unions of coal miners. The ordinary contributions to the Federation are fixed at 1d.

per member per quarter year. But funds when required are raised by means of levies on the various Unions as decided by conference of the Federation.

Four of the Coal Miners' Unions possessed—each of them—funds exceeding £100,000 at the end of 1913. The Derbyshire Union headed the list with £281,463 (or per member, £6. 18s. 2d.), next came Yorkshire with £238,432 (£1. 17s. 9d. per member), then Nottinghamshire, £152,305 (£4. 9s. 1d. per member), and Durham, £125,219 (17s. 11d. per member).

All four showed increases in their funds at the end of 1914, with the exception of Yorkshire, where large funds were spent on Dispute Benefit during that year.

The total funds of registered Miners' Unions at the end of 1916 reached over one and three-quarter millions.

Much less was spent during the war on Unemployment and on Dispute Benefits, and the funds increased accordingly.

The total funds of all registered Trade Unions on 31st December 1916 amounted to £10,518,299, of which nearly £2,000,000 were accumulated during that year—1916—a record increase! (Part A, General Yearly Reports of Chief Registrar of Friendly Societies.)

Within recent years Trade Unionism has developed novel characteristics, so much so that we hear of the new unionism, or the greater unionism, as distinguished from the old unionism. The distinction between them lies mainly in larger demands and a more aggressive spirit. This aggresive, not to say hostile, attitude of organized labour towards employers is the most disturbing and unfortunate feature of British industry.

Unless this spirit of hostility can be removed, and conflict give place to co-operation, between employers and workmen, there can do no doubt at all that British industry will go under. "A house divided against itself cannot stand."

If either Labour or Capital adopt the methods of Prussian militarism and depend on force, there will be social war, with all the loss and suffering that attend a state of war. But aggressive war will not succeed in the industrial sphere, any more than it has in the international and military sphere. Force is not the dominating principle in human progress.

Rather, in the words of Abraham Lincoln: " Right is might, and in that belief let us do our duty to the uttermost."

The new unionism is prepared to enforce its demands by methods of compulsion, such as the general strike, and has visions of an omnipotent labour party. The industrial unrest during the three or four years preceding the war was widespread and growing and unprecedented, though it was a period of rising wages and full work.

Under present conditions Trade Unionism appears to be essential to the protection and promotion of the interests of labour. This is largely the fault of bad employers and greedy capitalists. The natural and most beneficial Union for any industrial enterprise is one of all engaged in it, whether they bring labour, or brains, or capital, with a view to promoting their common object.

" Whatever may be done with the product of their work, employers and employed have a natural and inevitable partnership in the task of production. Co-operation between them is essential to any sort of success, and the best results can be obtained only when the co-operation is at its closest. . . . The co-operation required is personal and individual, able to mould itself to the individual problems of the works in which it is exercised, regardless of what may be the needs and limitations of the next work." (*Times Engineering Supplement*, June 29, 1917.)

But under present conditions without his Trade Union the individual workman would be helpless. Trade Unionism has useful functions to perform, but it can hardly be denied that in some of its recent developments it is a serious menace to the common good. It restricts output of work and generally reduces efficiency. It subordinates the interests of the industry to the interests of the Trade Union. It acknowledges no authority. It tends to reduce workmen to one level of mediocrity, and to take away all the enthusiasm of individual effort. It uses the severest measures of coercion to men outside the Union. In comparison with other classes, organized labour occupies a position of special privilege in the eyes of the law, under the Trades Disputes Act of 1906.

There is undoubtedly a dangerous anarchical element which has grown in connection with the labour movement during recent years, and if it overpowers the saner elements, there will be serious trouble.

"The most pernicious feature of the British Trade Unions is their policy of limiting output, and their hostility to improvements in organization and machinery. Their activity has upon the body economic an influence similar to a slow fever which leads, almost imperceptibly, t atrophy, to marasmus, and to death." (See *Nineteenth Century Magazine*, December 1915. "Britain's War Finance and Economic Future," by Mr. J. Ellis Barker.)

Restriction of output by workmen absenting themselves from work and limiting their production when at work, in obedience to the deliberate policy of the Trade Unions, acts as a blight on the coal-mining industry.

Some Miners' Unions have gone so far as to draw up rules, which they have printed and circulated among their members, regulating and limiting their day's work.

"Labour is dissociating itself from work. It is labouring all day, and bringing forth as little as it can!" ("A Sovereign Remedy," by Mr. F. A. Steel.)

This attitude towards work will soon spoil the best of workmen.

Too many miners are obsessed by the delusion that anything which is of benefit to colliery owners must be a disadvantage to the colliery workmen.

No doubt this attitude is largely due to the way in which workpeople have been treated in the past by their employers.

Limitation of output and opposition to improvements in organization and to machinery for increasing production are the workmen's response to the cutting of rates and the dismissal of workmen. Limitation of output by restricted effort when at work is more serious than that due to men absenting themselves from work. But it is difficult to estimate the effect in reduced output of restricted effort, whereas the effect of absenteeism can be shown in figures.

In the Report of the Departmental Committee (June 1915) appointed to inquire into the conditions prevailing in the coal-mining industry owing to the war, it is stated that absence from work over all classes of mine workers, on the days on which the mines were open to work, was, for the seven months preceding the war, an average of 10·7 per cent, and for the seven months succeeding the outbreak of war an average of 9·8 per cent, and that fully 4·8 per cent of this was avoidable absence. The avoidable loss of work amongst the coal-hewers, the men who actually get the coal, and who are the most highly paid, is very much larger than this.

In their case the absenteeism ranges from about 15 to 18 per cent, and their absence lowers the output of course more than the absence of other grades of labour.

As wages increase, the percentage of men off work increases also. The evil is greatest when wages are high.

Some of the absenteeism is due to aversion to paying income tax. The payment of income tax is a new experience for miners, and some of them seek to avoid it by keeping their earnings below the limit at which the tax becomes payable. Most people dislike paying income tax, but it is to be hoped that the miners in time may become reconciled to paying it like every one else.

In 1916, when in the national interests great efforts were being made to increase the output of coal, the South Wales Conciliation Board appointed a sub-committee to investigate this matter of absenteeism.

Returns were obtained from 275 collieries employing underground about 134,000 men.

For the six months ended December 16, 1916, the percentage of avoidable absenteeism, that is, the number of shifts lost through workmen not attending though able to do so, amounted to 8·05 per cent.

The number of shifts lost each week from avoidable causes ranged from 58,400 to 161,455, and the total absenteeism over the whole period amounted to 2,287,485 shifts.

The loss of work was largest on Mondays, though the previous day, Sunday, is a holiday.

The Coal Mines Organization Committee stated in their Third Report (published September 1916) with regard to the whole country, that were the avoidable absenteeism wiped out it would result in an increased annual output of about 14,000,000 tons.

Probably most of the absenteeism occurs amongst only a section of the whole body of miners—perhaps a comparatively small section. Certainly there are many miners who seldom lose a day's work if they can help it.

At a group of Lancashire pits employing about 1000 coal getters, a list of wilful absentees was kept for each day during two months. This showed that the wilful absenteeism was confined to about 18 per cent, or less than one-fifth of the men, whilst the other four-fifths, or the large majority, were regular in their attendance. (See *Trans. Inst. Mining Eng.*, vol. i. Presidential Address by Mr. Leonard R. Fletcher.)

But the ca' canny idea is widely prevalent and clogs the wheels of progress. As Mr. Harold Cox has expressed it: "We shall get no real progress until you can demonstrate to the working classes as a body that their individual and collective interest lies in more efficient production."

A greater output of work with a diminished cost of production, and higher wages for the hand-worker with less physical exertion, are the ideals for the industrial development of the future. They can be secured by a more extended use of machinery and a more scientific use of human muscles. (See Address by Harold Cox on "Industrial Development" at Inst. Civil Engineers on March 7, 1910.)

Better wages and better conditions of living must be accompanied by better output of work.

It is by increased production that the total wage fund is increased. Limitation of output limits also the fund from which wages are drawn. Production is increased by the employment of improved appliances and processes, with willing hands and brains to work them. In the coal-mining industry labour receives about 70 per cent of production, and therefore any increase is mainly for the benefit of labour. Labour is much more largely concerned in increased production than is capital. The bulk of the national income goes to the wage-earners.

As Sir William Lever, M.P., now Lord Leverhulme, has said : " Restriction of output is not only an economic fallacy, but is the robbery by the worker of his mates of their rightful due in wages, food, clothing, houses, and welfare conditions."

Restriction of output dries up the sources of wealth.

The ideal Trade Union would consider and promote the skill and the effective and regular work of its members no less than their wages.

But the labour movement is only one feature—though perhaps the most important—of a period of transition towards a greater social efficiency — a higher type of civilization.

The factors making for social and economic change are many and powerful.

The progress of education ; greater opportunities of self-improvement ; the growth of the halfpenny press and of cheap literature ; increased facilities of travelling and communication by the spread of trams and motor-buses and cheap railway excursions ; easier means of recreation and entertainment, the multiplication of picture palaces and music halls—all these things subtly but surely are changing the standard of living and the views and aspirations of the people.

The war is a phenomenon by itself, which must have a big effect, bringing new ideas, removing prejudices and national conceit, and generally shaking people out of old ruts. It has shown the inadequacy of some of the most cherished of British characteristics, such as "go-as-you-please" individualism, and "muddling through somehow," and one-sided trade.

Labour has been called upon on behalf of the nation for greater exertions and sacrifices than ever previously. It has realized its national value, and one effect of the war has been to quicken the determination of labour to gain a better status.

There is also the prevailing sentiment, which now pervades all classes, and which is based on the deepest springs of human nature, that the manual workers should have all the advantages possible. At bottom it is an ethical question, and will be evolved according to the ethical tone, the operative sentiment, the common ideal, which prevails throughout the whole community. Certainly the manual worker is entitled to as high a standard of comfort as any other man; *but the material advantages possible are limited by economic conditions.*

The wealth of a nation depends on the productive power of its people. The development of the material resources of the world and the increase of wealth are due primarily to the great inventors and discoverers and organizers, to the far-sighted business men of courage and enterprise, to the pioneers and merchant-adventurers—in short, to the comparatively few men of exceptional abilities.

Wealth must be produced before it can be distributed. The available sources of wealth at any one time are not unlimited, and the actual wealth produced from them is proportionate to the human energy and judgment and skill and efficiency with which they are exploited. Capital, and labour, and business ability, and technical knowledge and skill, are all required for their development, and any one of these essentials is useless without the others. How can they be best developed and their product distributed, so as to secure the highest advantage of the whole community? This is the great problem to be solved. It will not find a neat and definite solution like a problem in Euclid, but is rather a matter of gradual evolution wrapped up with human progress.

Various methods of treatment are advocated. State control; collectivism or socialism; the nationalization of mines and minerals; profit-sharing or copartnership between labour and capital; *laissez-faire* or liberty for the free play of conflicting interests—all these systems or principles have their adherents and supporters. One principle may be laid down with certainty, namely, that in any industry, methods of goodwill and mutual co-operation will bring better results for all concerned than will selfish, grasping, fighting methods, or outside interference.

To quote from an article entitled "The Mind of the Working Class" in *The Times Literary Supplement*, July 19, 1917:

"So long as industry is conceived not as a co-operative process for supplying the community with what it needs, but as a struggle for profits and wages, or as a balance of power between two rival forces contending for plunder, domestic politics will remain under the cloud which overshadows them to-day. But when the ideals of public service and intelligent and disciplined co-operation, which have been tested in other fields, are once applied to industrial problems . . . the working class will at last find a solid foundation on which to build up a native English industrial programme of its own."

The increasing intervention of the Government during recent years, far from mitigating the trouble, has increased it.

When employers and workmen think that matters in dispute will be settled by a Government Department, they are less likely to come to an agreement between themselves, and they are more likely to increase their demands. And an agreement made under Governmental intervention is not accepted with the same cordial assent as one made by mutual consent.

Independently of the special measures due to the war, State control, which means the subjection of the industry to a group of officials who are more or less under the influence of party politicians, has made rapid headway, especially in the coal-mining industry. The Coal Mines Regulation Act, 1908, the Coal Mines Act, 1911, and the Minimum Wage Act, 1912, and the increased number of Government Inspectors have gone far to bring the industry under bureaucratic control, but this will be considered in a subsequent chapter.

British industry has been built up in the past mainly by individual and independent effort, assisted by the natural advantages of abundant supplies of cheap coal with ready access by sea to the markets of the world. Individualism is a typical English characteristic. But under modern conditions something more is required. Individualism cannot compete with well-organized combination. The good old principle of "Each for himself, and the devil take the hindermost" is no longer practicable. It must be replaced by the more excellent precept, "Each for all, and all for each." "The eye cannot say to the hand, I have no need of thee; nor again the head to the feet, I have no need of you." In short, we want more co-operation and co-ordination. "Patience in scientific co-operation" is needed as well as "Capacity of individual initiative." It has been truly said of the coal-mining industry that the future bristles with difficulties.

CHAPTER VI

THE LABOUR PROBLEM

LIKE men generally, the miners want a fuller and freer life and a larger share of the available wealth, a very natural and not improper desire.

They have made substantial progress within recent years. Wages are higher, the conditions under which they work are greatly improved, and they have more leisure. In all these ways there has been marked advance.

But these material gains, far from mitigating industrial strife, have rather aggravated it. General advances of wages, and privileges granted to hundreds of thousands of men as a body, do not afford lasting satisfaction to the individual workman. Labour in the mass consists of a multitude of individuals of very varying capacities and temperaments. The miners are not a uniform and colourless mass. A man needs some recognition of and respect for his individual personality. The average man will not feel satisfied unless he can take some pride and pleasure in his work, and can see some prospect of progress and advancement arising from his exertions. Otherwise his work becomes monotonous drudgery. He has no inducements to take interest in it. A man can hardly be a good workman, unless his work is a living interest to him.

The industrial trouble has been well diagnosed and methods of reform proposed in a little book, "Labour Unrest," by George Edson Toogood (1915). The general thesis is that labour problems may be mastered by employers working with and through Trade Unions, with the State to see fair play and enforce rules, and to guard the interests of the community. But Trade Unions must reform their ways. They should regard the quality as well as the quantity of their membership. They should have a public test of fitness for membership. They should enforce rules governing the character and conduct of their members dealing with such matters as loss of work and drunkenness or other misconduct. After the analogy of the General Medical Council, and the Incorporated Law Society, whilst protecting the rights of their members, they should in no way restrict their possible achievements.

They should consider and promote whatever tends to the improvement and to the increased production of their industry. At present their attention is directed mainly to securing a larger share of the profits, but they should consider also how the profits may be increased.

"Trade Unions must no longer be a power seeking to control. In civilized government communities should regulate for themselves the interests their members have in common, and submit to the impartial rule of the State such divergent interests as individuals cannot safely be left to control for themselves. This principle should be applied to industry. Where control is necessary, the State must exercise it, and, relieved of the temptation to embark on dangerous conflict, trade union influence and ability will become what it should be—a source of information, discussion, and persuasion, not a focus of constraint and disturbance." (*Times Engineering Supplement*, June 22, 1917.)

There should be discrimination amongst workmen according to character and conduct and merit.

Exceptional merit should be not only encouraged and rewarded, but honoured. "The only solution is in the recognition of the fundamental fact that one man is better than another, and must be rated and placed according to his real value."

The total wage fund is limited by economic conditions, but it would not be diminished by a scientific redistribution of the individual share. Wages should be paid according to individual efficiency.

Trade Unions working on these lines would receive the hearty support of the employers.

It cannot be denied that the general attitude of organized Labour—the attitude of suspicion and distrust towards Capital—is due in a large degree to the ruthless conduct of unscrupulous employers. If all employers had always treated their workpeople with sympathy and justice, the Labour problem would not exist. At bottom the trouble springs from treating men as money-making machines instead of as human beings.

In past generations Labour was treated as "the cannon fodder of industry," and we are reaping the result to-day. (See "The Town Labourer, 1760–1832," by J. L. Hammond and Barbara Hammond.)

"The real crux of the whole matter is the bad employer, by which I mean a grasping, bullying, or underhand treatment of labour. . . . Employers, like workmen and the rest of us, are of all sorts, good, bad, and indifferent." (See "The Coming Revolution," Dr. Arthur Shadwell, *Nineteenth Century Magazine*, July 1917.)

Employers, who are the organizers of industry, should get rid of prejudice against high wages and be content with moderate profits. They should never make good work, or increased production per man, a reason for lowering piecework rates or reducing wages, and they should be ready to share with their workmen in prosperity. The rendering of the best service to the community, not money-grubbing, should be the guiding motive. A man's life does not consist in the abundance of his possessions. To quote the words of a large employer: "Unless industry is recognized as primarily a national service in which each individual is fulfilling his function to the best of his ability for the sake of the community, in which, in a word, we carry out our duty towards our neighbour—unless we build on this foundation there is no hope of creating the house beautiful. If each man thinks of making his pile by all the means that economic individualism allows, if class bands itself against class, trade union against employers' federation, firm against firm, to secure the greatest share of the world's goods in unrestricted competition, social life must inevitably break down, and anarchy reign supreme." (W. L. Hichens, chairman of Messrs. Cammell Laird & Co. Ltd. James Watt Anniversary, lecture delivered on January 18, 1915, before the Greenock Philosophical Society.)

High wages are not inconsistent with economical production. It is the cost of labour that concerns the employer, not the amount of wages paid. With improved machinery the cheapest labour is often, perhaps usually, the best paid labour. Employers should exert themselves to win the confidence of their workmen. The trouble is largely due to the displacement of the individual employer by joint-stock companies. The directors of these companies, in their control of affairs, are guided mainly by a consideration of the financial interests of their shareholders, but if the Labour trouble is to be removed, they should consider as well the financial and other interests of their workmen. The health and happiness of the workers should be one of their first considerations.

As Mr. G. H. Roberts, M.P., when Minister of Labour, has remarked, "The impersonal nature of the relation between employer and employed is the greatest blot on modern industry."

High wages alone will not satisfy Labour.

"Man does not live by bread alone." A materialistic view of human well-being will always lead to disappointment. "There is undoubtedly a growing feeling of dissatisfaction on the part of workpeople with what they regard as their position of inferiority due to a forced submission to undesirable conditions, and to the subjection of the worker both to the machine and to the will of others who are vested with an authority in which the workers have no share. One of the most insistent demands made by the rising generation of workers is for what is called 'Industrial Control.'" (Interim Report of Committee on Adult Education, September 1918.)

In his address as president of the Trade Union Congress at Birmingham in September 1916, Mr. H. Gosling expressed the aspirations of organized labour as follows:—

"Would it not be possible for the employers of this country, on the conclusion of peace, when we have rid ourselves of the restrictive legislation to which we have submitted for war purposes, to agree to put their business on a new footing by admitting the workmen to some participation, not in profits, but in control?

"We workmen do not ask that we should be admitted to any share in what is essentially the employer's own business, that is, in those matters which do not concern us directly in the industry or employment in which we may be engaged. We do not seek to sit on the board of directors, or to interfere with the buying of materials, or with the selling of the product. But in the daily management of the employment in which we spend our working lives, in the atmosphere and under the conditions in which we have to work, in the hours of beginning and ending work, in the conditions of remuneration, and even in the manner and practices of the foremen with whom we have to be in contact, in all these matters, we feel that we, as workmen, have a right to a voice—even to an equal voice—with the management itself. Believe me, we shall never get any lasting industrial peace except on the lines of industrial democracy."

Similar ideas have been expressed by another labour representative, Mr. William Straker, the corresponding secretary of the Northumberland Miners' Union:—

"So long as a man is under the control and direction of another's will, without either knowledge or will of his own as to the ultimate purpose of his labour, there will be, at least in his sub-consciousness, a sense of slavery which begets unrest, even though the man himself does not understand the cause of all his dissatisfaction. The only remedy is not only to allow, but to train the man to understand all about the industry he is engaged in, and its co-relation to other industries. Train him in a knowledge of the commercial side of his industry; let him feel that he has a part and lot in all that pertains to the work of his own hands or brain; let him share in the control and management, so that he will feel that it is his will in conjunction with other wills that is at the helm of all that concerns himself and the work he is engaged in; let him adequately share, and clearly understand his share, and the share of others, in the fruit of his and their labour; do these things and you will destroy that sense of slavery to the will of another which is at the root of all his unrest."

If industrial enterprise is to prosper in this country, there must be development somewhat on these lines.

Tending in this direction are the recommendations contained in the Reports of the "Reconstruction Committee on the Relations between Employers and Employed" (the "Whitley" Committee appointed in October 1916).

They recommend the establishment for each industry of an organization, representative of employers and workpeople, to have as its object the regular consideration of matters affecting the progress and well-being of the trade from the point of view of all those engaged in it, so far as this is consistent with the general interest of the community.

These "Joint Standing Industrial Councils" are to be supplemented by District Councils representing the Trade Unions and Employers' Associations in each district, and by Joint Committees representing the management and the workpeople of each workshop or industrial unit.

In their report the Committee very truly remark that improved relations between employers and employed must be founded on something other than a cash basis.

"What is wanted is that the workpeople should have a greater opportunity of participating in the discussion about and adjustment of those parts of industry by which they are most affected."

A wide range of subjects to be discussed and handled by these Councils are suggested, such as the provision of facilities for the full consideration and utilization of inventions and improvements designed by workpeople, and co-operation in carrying new ideas into effect and full consideration of the workpeople's point of view in relation to them.

In the coal-mining industry much of this proposed organization exists already. Much time and energy are expended on discussion. Labour representatives as a rule are fond of airing their opinions. To say nothing of the more important bodies, such as Conciliation Boards and Joint Committees, most colliery managers devote a good deal of their time to meeting deputations of their workmen, and discussing divers questions that arise. But if such discussions tend to promote understanding and goodwill, as probably they do generally, they should not be regarded as wasted effort.

The formation of the "Industrial League" and of the "National Alliance of Employers and Employed" shows that the right spirit which ought to prevail is alive and active.

The great end to be achieved is to bring about the community of interest and the goodwill between employers and employed which is natural amongst men engaged in furthering a common object to their mutual benefit—that understanding and respect which does exist in some instances where employers have devoted themselves whole-heartedly to bringing it about.

Then none was for a party,
  Then all were for the State;
Then the great man helped the poor
  And the poor man loved the great.
Then the land was fairly portioned
  And the spoils were fairly sold;
The Romans were like brothers,
  In the brave days of old.

"L'union fait la force."

CHAPTER VII

ACCIDENTS AND DISEASES

THE most painful feature of the coal-mining industry is the heavy toll it takes on human life by accidents causing death or injury. In the year 1913, 1731 persons were killed and 174,273 persons suffered injury disabling them for more than seven days; but the deaths for 1913 were swollen by the disastrous explosion at Senghenydd Colliery in South Wales which carried off 439 persons, the largest number ever killed by one explosion in the United Kingdom.

The average number of deaths per year for the preceding five years was 1390, made up as follows:—

Falls of ground	588·8
Miscellaneous [1]	366·8
Explosions	200·8
Shaft accidents	84·4
Surface accidents	149·8
	1390·6

A true view of the progress made in the prevention of accidents in coal mines can only be obtained by taking them in relation to the number of persons employed, or in relation to the output of coal, and over periods of years.

During the ten years 1873 to 1882,[2] the average yearly death-rate from accidents per 1000 persons employed at mines under the Coal Mines Acts under and above ground was 2·24, and per 1,000,000 tons (2240 lb.) of mineral raised it was 7·42. The following Table gives the corresponding figures for the three succeeding decades:—

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[1] The heading Miscellaneous includes all underground accidents other than those from explosions of firedamp or coal dust, falls of ground, and shaft accidents.

[2] These comparative figures are taken from the Home Office Report by the Chief Inspector of Mines, and include all mines coming under the Coal Mines Acts.

DEATH-RATE BY ACCIDENTS.

Decade.	Per 1000 Persons employed.	Per Million Tons of Mineral raised.
1873–1882	2·24	7·42
1883–1892	1·81	5·65
1893–1902	1·39	4·70
1903–1912	1·33	4·76

These figures show that there has been marked improvement during the last thirty years, the reduction in the death-rate by accident per 1000 persons employed in the decade 1903 to 1912, as compared with 1873 to 1882, being no less than 40·5 per cent.

In 1851 about nineteen persons were killed per 1,000,000 tons of coal raised from mines in the United Kingdom, which again shows the substantial progress that has been made.

Compared with other coal-producing countries Great Britain stands very well. For the ten years 1901 to 1910, the number killed per 1,000,000 short tons (2000 lb.) of coal produced in the principal coal-producing countries was lower in Great Britain than in any other country except New South Wales. The figures are: Japan, 22·71; India, 9·00; France, 7·79; Germany, 7·53; United States, 5·83; Belgium, 5·56; Austria, 5·05; Great Britain, 4·40; New South Wales, 3·70.

Per 1000 persons employed, Great Britain comes fourth in the list, the rates for the same decade being: United States, 3·74; Japan, 2·92; Germany, 2·11; New South Wales, 1·74; France, 1·69; Great Britain, 1·36; Austria, 1·04; Belgium, 1·02; India, 0·96.[1] (See Bulletin No. 69, published by United States Bureau of Mines.)

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[1] For the purpose of comparison these figures are only approximately correct. To be accurate the hours worked should be the same in all cases, and the rates should be based in all cases on the number of workers actually employed, and not—as they sometimes are—on the number on the books.

It should not be forgotten that Great Britain employs a considerably larger number of persons in coal mining than any other country, though it has not the largest output of coal. There are a large number of collieries every year which are quite free from accidents. In 1913, 1140 mines out of a total of 3289 under the Coal Mines Act, made returns showing that no accidents had occurred. Owing to varying natural conditions, the risks at some collieries are much greater than at others.

For the ten years 1903 to 1912, the average death-rate by accident underground, as classified in the Home Office Report, is as follows:—

Falls of ground .	0·74
Miscellaneous . .	0·44
Explosions of firedamp or coal dust .	0·17
Shaft accidents .	0·11
From all causes underground . .	1·46 per 1000 persons employed underground.

"Falls of ground" cause far the largest number of accidents. Since 1873, on a average, about half the annual death-rate underground is due to "Falls of ground." Far the greater number of these accidents occur at the working face and not on the roads.

Next to "Falls of ground," "Haulage" (included in "Miscellaneous") is the most dangerous source of accidents.

Most of them are due to persons being run over or crushed by trams or tubs. Two hundred and eleven persons were killed in this way in 1913, besides eight by ropes or chains breaking, and twenty-nine in other ways, making a total of 248 deaths due to underground Haulage.

Many of the accidents under both these heads might be avoided by greater care on the part of the individual workman. Figures to this effect were given by Mr. Hugh Johnstone, H.M. Inspector of Mines, in his presidential address to the South Staffordshire and Warwickshire Institute, on October 11, 1909. They are based on a record kept of the opinions of the Inspectors of that district as to whether the accidents investigated by them were preventable, and if so, who was responsible for their occurrence. They cover a period of two years, and relate to the death or injury of over 600 persons.

	Killed or Injured. Per cent.
Owing to defective plant	1·27
,, neglect or breach of rules by officials .	1·75
,, neglect or breach of rules by workmen .	9·08
,, causes which were preventable by the exercise of greater caution on the part of the persons killed or injured, or of their fellow-workmen. . . .	35·03
,, causes which, broadly speaking, were unpreventable	52·87
	100·00

These figures show that about one-third of the total accidents might have been prevented by the exercise of greater caution on the part of the workmen, and there can be little doubt that this is true generally.

It is a remark that occurs frequently in the annual reports of the inspectors of mines, that with ordinary care many of the accidents ought not to have happened.

Similar figures relating to fatal accidents in mines in the Union of South Africa point to the same general fact, that greater care on the part of the workmen would prevent many accidents.

(See paper by Mr. Albert H. Fay of the U.S. Bureau of Mines, read before the Second Pan-American Scientific Congress held in Washington on December 31, 1915.)

The figures cover 200,000 employees for a period of two and a half years from July 1, 1911, to December 31, 1913, and were taken out by the Government Inspectors.

RESPONSIBILITY FOR FATAL ACCIDENTS DUE TO HAZARD OF INDUSTRY.

	Number killed.	Percentage.
1. Danger inherent to work or misadventure	1399	56·03
2. Defective plant or material	98	3·93
3. Fault of injured person—		
Carelessness	204	8·17
Ignorance	56	2·24
Disobedience of order	167	6·69
4. Fault of management	56	2·24
5. " foremen	283	11·33
6. " others	148	5·93
7. Joint fault of 3, 4, 5, and 6	86	3·44
	2497	100·00

According to these figures 17·10 per cent of the fatal accidents were due to the fault of the injured person; and 17·5 per cent—practically the same proportion—to defective plant or material, fault of management, or of foremen—in short, to the fault of the employer or operator.

Some large colliery companies have effected a marked improvement by appointing a man to do nothing else than to instruct and to stimulate their workmen in the best way of taking care of themselves. Much, no doubt, depends on getting the right man for the job. He should be perhaps a man of their own class to whom the miners will take kindly, and not a colliery official. He goes round amongst them when they are at work, pointing out to them matters that want attention, and risks to be avoided, and periodically, say once a week, he holds a meeting at some convenient centre for the workmen, and addresses them on the subject.

During the ten years 1898 to 1907,[1] 5014 persons were killed by "falls of ground." This is 57·8 per cent of the total deaths underground from accidents during this period. Of the 5014 deaths

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[1] These figures are taken from a Report of a Committee, appointed by the last Royal Commission on Mines, to inquire into the causes of, and means of preventing, accidents from falls of ground, underground haulage, and in shafts (1909). Many of the provisions and regulations of the Coal Mines Act, 1911, are based upon this Report.

64·9	per cent	were	at the working face.
19·8	,,	,,	on roads while repairing or enlarging.
14·8	,,	,,	on roads while otherwise working or passing.
0·5	,,	,,	in shafts.
100·0			

Of the accidents in the Working Face, most occur to men whilst they are "holing" or undercutting the seam, or getting down the coal. The "withdrawing" of timber and the setting of props causes, too, a large proportion of the accidents in the Face. Some remarks by Mr. H. Walker, the Inspector for the Scotland Division in his Report for 1917 on the prevention of accidents from falls of roof and sides are worth noting: "The question of adequate support being given to roof and sides is, after an efficient system has been arranged, one of *discipline*. To arrive at an efficient system suitable to the conditions existing in any seam is the duty of the manager of each mine, aided by his officials. . . . But no system, however perfect, is of much value unless the carrying out of it is rigidly enforced, and it is in this regard that the necessity for very *strict discipline* arises. . . . On a system being decided upon, models of it should be set up on the surface. Sketches are of little value, but full-sized models which a miner could inspect at his leisure, would show to him exactly the manner in which the supports were to be set and advanced."

During the same ten years (1898–1907), 22·6 per cent of the total deaths underground were due to "haulage." Thus 80·4 per cent of the total deaths came under these two headings.

Half the "haulage" accidents, 50·2 per cent of them, occurred to men and lads whilst engaged as "riders" on the sets of tubs, or as hauliers, drivers, putters, etc.; 14·9 per cent of the total met their death when walking inbye or outbye to or from their work.

Other sources of accidents coming under the heading "Miscellaneous" are "by explosives," which in 1913 accounted for 29 deaths; by underground fires, 25; by machinery, 17; electricity, 13; irruption of water, 9; suffocation by natural gases, 5.

Ninety-eight men were killed in 1913 by accidents in shafts, which include overwinding, 16; falling into shaft from surface and from part way down, 29; whilst descending or ascending by machinery, 14; ropes or chains breaking, 2, etc.

"Explosions of firedamp or coal dust" account for only about 10 per cent of the total killed during the ten years 1903 to 1912. But this source of accident bulks most largely in the public estimation, because of the large numbers often killed by a single accident. Other accidents are much more frequent, but they do not carry off so many at a time.

In 1913 there were 1198 separate accidents, causing the death of 1731 persons, but one of these accidents, namely, the explosion at Senghenydd, killed 439 persons.

Coming now to accidents above ground, for the ten years 1903 to 1912, the mortality rate per 1000 persons employed above ground was 0·78. The average number killed each year over these ten years was 145. Here again, as below ground, "haulage" is a most fruitful source of accident. During 1913, twenty-four persons were run over while passing along or across railways or tramways, nineteen were killed while engaged in moving wagons, fourteen were crushed between wagons and structures—in all, eighty-six were killed on railways, sidings, or tramways. Twenty-seven deaths are classed as due to "Machinery."

It is satisfactory to note that only three deaths were due to electricity above ground, and thirteen below ground, testifying to the safety of this form of power, which is extending so rapidly in coal mines, see page 86.

NON-FATAL ACCIDENTS

The large number of non-fatal accidents causing injury brings home the danger of coal mining perhaps even more forcibly than the number killed.

The causes are the same.

In 1913 these minor accidents ran up to the record number of 174,273, giving a rate of 157 per 1000 persons employed. They are classified as follows:—

Underground—	
Miscellaneous	98,646
Falls of ground	61,178
Shaft accidents	821
Explosions of firedamp or coal dust	128
	160,773
Above ground	13,500
	174,273

For the preceding five years the average number per year was

Miscellaneous	85,103
Falls of ground	54,470
Shaft accidents	804
Explosions	152
Surface accidents	11,187
Total	151,716

The comparative increase in recent years is accounted for to a large extent by the fact that for purposes of insurance under the Workmen's Compensation Act many accidents which were considered formerly too trifling to report are now reported.

This long roll of accidents produces a plentiful crop of disease and disablement. The most general period of disablement is a fortnight to a month, but something like 12,000 miners are incapacitated annually for a full year or more.

Referring to this in his Milroy lectures before the Royal College of Physicians, London, 1914, Dr. Frank

Shufflebotham states: "This large number does not only represent so many broken bones or lost limbs, but it includes many diseased conditions directly set up as a result of the injury they have sustained, and medical men who work in colliery districts have almost daily experience of the effect of trauma as a causation of disease, or the aggravation of some pathological condition which had previously existed." Tuberculosis and many other diseases, especially nervous diseases, may be set up, or certainly may be aggravated as the result of an injury.

"The commonest nervous sequela of all kinds of injuries amongst miners is neurasthenia. I do not suppose that there is any class of men so liable to this condition as colliers, and I attribute this frequency to the dangerous nature of the colliers' work, and to the influence of heredity. There is no industry where heredity plays such an important part as in the mining industry. Officials and workmen alike are sons and grandsons of those who have worked in the pits before them. . . . The nature of the work and heredity are the two predisposing causes. The exciting cause is some injury, generally an injury to the back, of a comparatively trivial character."

Much of the existing disease and disablement amongst coal miners might be prevented by early and effective treatment. There is a need of more Sanatoriums or Convalescent Homes under the charge of competent medical men who have had experience in colliery districts. A week or more spent at such institutions at a health crisis would save many a coal miner from becoming invalided and incapacitated.

It is noteworthy that it is disease of the nervous system—e.g., neurasthenia and nystagmus—from which coal miners suffer most.

The prevention of accidents is largely a matter of education. This is well expressed in a paper (" Safety Methods and Organization of United States Coal and Coke Company," by Howard N. Eavenson. *Trans. American Inst. of Mining Eng.*, 1915).

"The great question is to reach the man who is actually doing the work at the working face with the superior knowledge and experience of the higher officials, and this can only be done by a system of detailed supervision and instruction. . . .

"Any work of this kind requires unceasing vigilance, careful supervision, and the never-ending stimulation of the spirit of care in all those having anything to do with it."

"The first essential to success is the recognition of the fact that it is the duty of the employer, as far as possible, and by every means in his power, to prevent injury to the employees."

In the U.S.A., where there is a good deal of room for improvement, increased attention has been paid latterly to the prevention of accident in coal mines, and somewhat original methods have been devised. In co-operation with the United States Bureau of Mines, one large company has prepared about 4000 feet of moving picture film, showing the complete details of the proper methods of mining. These pictures are exhibited to their miners with the object of showing them exactly how the work should be done with safety and efficiency. "Anything that tends to promote the efficiency of mining will undoubtedly in the long run promote its safety; and the safest mining will undoubtedly prove to be the most efficient."

A system of monthly cash bonuses to the overmen and under-officials whose districts are free from accidents has been tried with success. This bonus is not considered as a part of the wages, but is strictly in the nature of a reward for faithful services rendered to the company in the prevention of accidents. The details of this and of other methods that have been adopted and their successful result are set out in the paper mentioned.

In the U.S.A. also increased safety from accidents has been achieved by a system of co-operation between colliery owners and insurance companies with a view to meeting the liabilities enforced by Workmen's Compensation Acts. The acts which are in force in several of the States, e.g., Pennsylvania, Illinois, and Colorado, make it compulsory for the colliery owner to insure as a guarantee of his ability to meet his obligations under the Act.

Mining engineers appointed by the Insurance Companies inspect the collieries and fix the rates that have to be paid according to the relative safety conditions of the colliery.[1]

By the combined efforts of the Bureau of Mines, the State Mine Inspectors, the Colliery Managers, and Representatives of the Workers' Unions, there have been established schedules of insurance rates varying according to the condition of the mine as regards risks of accidents and the precautions adopted. These rates are based on the past records of accidents under all the different heads in their percentage proportions, furnished by the statistics of each State, and checked by the average for the whole U.S.A.

From a careful analysis of the causes of the accidents, a numerical value is fixed for each cause, and modifications of these values are assessed on the credit side for safety precautions, and on the debit side for special risks.

The engineer of the Insurance Company when inspecting a mine in order to assess the rate, calls the attention of the management to points affecting safety which may have been overlooked, and recommends measures that may be adopted, and by attention to such points a considerable reduction in the premium to be paid may be effected.

Several examples are given. To take one, namely, the Oakdale mine of the Oakdale Coal Co., Colorado. At the first inspection on August 18, 1915, the rate fixed was 6·62 dollars (27s. 7d.) per cent—a very high rate—which made a total annual premium payable yearly of 15,120 dollars (£3150).

A year later on July 27, 1916, when another inspection was made, the safety measures had been so much improved that the rate was reduced to 4·70 dollars, or 19s. 7d., making the total premium for the year 11,280 dollars, or £2350, a reduction of £800.

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[1] See "Merit Rating of Coal Mining under Workmen's Compensation Insurance," by E. C. Lee. *Trans. American Inst. of Mining Eng.*, 1917.

But more important than the financial economy is the reduction in the number of accidents. As the system has only been in operation for a year or two, it is rather too soon to gauge its full effect in this respect. But in the State of Pennsylvania the number of fatal accidents was reduced from 1030 in 1915 to 989 in 1916, a reduction of 41, with practically the same output of coal. This good result may justly be attributed in part at any rate to this system.

A leading colliery owner in Pennsylvania, writing to the Insurance Company, says:

"The operating officials at our different properties were first inclined to be a little sceptical and critical, believing that no inspector acting under State or insurance authority could show them how to improve the conditions of their mines. Since we have gone through it, however, it gives me great pleasure to say that we have found your inspection of great service to us. Your inspectors have disclosed conditions which have enabled us to remove hazards, so that our properties are in far better condition as regards safety, and the change we have made in our organization and in our methods puts us in close touch with our working force, with the result of increased efficiency and economy in operation. We will be more than repaid for the expense we have been put to in making the changes recommended."

Experience under this system of insurance has led to a classification of the accidents under two heads, namely, those due to "Physical Hazards of the Mines," and those due to the "Human Element," i.e., to the carelessness, or ignorance, or negligence of those employed. In fixing the rates for safety precautions 60 per cent is allowed for "Physical Hazards" and 40 per cent for the "Human Element or Moral Hazard." In other words, it is estimated that if all persons employed, both officials and workmen, were alert and vigorous and thoroughly competent for their work, 40 per cent of the accidents would be saved. There can be little doubt that a strong healthy man, concentrating all his faculties on what he is doing, will be likely to avert accidents which would readily befall a weakly, ailing man whose heart is not in his work.

Modern investigations in other directions, such as "welfare work" and the productive capacity of manual labour, are bringing into prominence the same feature, which has been disregarded sometimes in the past, namely, the importance of the human element. The strong, healthy, and willing worker is worth a great deal more than the discontented, weakly, and careless man.

The prevention of accidents is being handled in the U.S.A. with vigour and originality.

Some companies have a Safety Inspector whose services are devoted solely to safety work, and who is responsible to the management for the adoption and enforcement of safety measures. (See "Organizing Safety Work in Mines," by H. M. Wilson and J. R. Fleming. U.S.A. Bureau of Mines Technical Paper, 103.)

In spite of the steady improvement in the prevention of accidents in coal mining in the United Kingdom which has been achieved, yet, compared with other occupations, it still ranks as one of the most dangerous. The best available data on this question is Dr. John Tatham's report to the Registrar-General issued in 1908. It is based on the enumerated population at the census of 1901 and on the registered deaths in the three-year period 1900–02. Similar reports having been made every ten years, since the three-year period 1870–72, they afford a means of comparison.

Dr. Tatham's report corroborates the steady decline in the death-rate by accident amongst coal miners, but still during the three year period 1900–02 it was more than double that of all occupied males.

Taking 100 to indicate the latter, the figure for coal miners was 208.

Of the total deaths *from all causes* during these three years amongst occupied coal miners of fifteen years of age and upwards, about 15 per cent (namely, 2806 out of a total of 18,855) were due to accidents.

There were only three occupations in which the death-rate by accidents was higher, and these are classified in the report as seamen, bargemen, and fishermen.

The sea is more dangerous than the mine.

But it is a relief to find that in spite of the high risk of accident, the death-rate *from all causes, including accidents,* amongst coal miners is much below the average of all occupied males. Taking the latter at 100, as before, the figure for coal miners was only 88.

The comparative figures at different ages of the mean annual death-rate per 1000 from all causes are as follows:—

Ages.	All occupied Males.	Occupied Coal Miners.
15 to 20 years	2·44	3·20
20 ,, 25 ,,	4·41	4·47
25 ,, 35 ,,	6·01	4·93
35 ,, 45 ,,	10·22	7·65
45 ,, 55 ,,	17·73	14·67
55 ,, 65 ,,	31·01	35·98

These figures show that coal miners from twenty-five to fifty-five years of age enjoy a striking advantage over the average population in immunity from death, in spite of their dangerous occupation.[1]

The death-rate from every class of disease amongst coal miners was lower than the average, with the one exception of diseases of the respiratory system. In this class the figure for coal miners is 111, as compared with 100 for the average of all occupied males.

Coal miners are singularly free from phthisis or consumption of the lungs, but bronchitis appears to be a disease to which they are especially liable.

Dr. Haldane has expressed an opinion that men engaged in occupations entailing great muscular exertion, such as coal miners, carmen, and coal heavers, are especially liable to bronchitis as they grow old, after the age of sixty-five, owing probably to overstrain of the lungs caused by laboured breathing.

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[1] In a letter to the *Times* of March 12, 1919, Dr. Haldane has given more

In his third Milroy lecture in March 1914, Dr. Frank Shufflebotham, medical referee under the Workmen's Compensation Act for the North Staffordshire District, states that fibrosis of the lungs, or miners' phthisis, which was formerly, owing probably to defective ventilation, one of the principal diseases from which miners suffered, is now practically non-existent. There is good reason to believe that coal dust in the lungs exerts a real protective influence against the tubercle bacilli.

The natural dust found in coal mines, though black in colour, is seldom pure coal dust, but contains varying admixtures of stone dust from the adjacent beds of stone which are cut into during the process of the working of the coal seam.

The immunity from dust explosions of collieries in the

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recent figures as follows. They differ slightly but not materially from the figures given above.

DEATH-RATE FROM ALL CAUSES PER 1000 LIVING IN EACH AGE PERIOD.

	Age Period.			
	15-25	25-35	35-45	45-55
All occupied and retired males . .	3·5	6·3	10·9	18·7
Occupied and retired coal miners .	3·8	5·1	8·0	15·2
Occupied and retired barristers and solicitors	—	4·9	7·6	13·8
Occupied and retired shopkeepers .	3·1	5·6	9·4	16·4
Occupied and retired doctors . .	—	5·6	10·6	18·5
Occupied and retired farm workers .	2·4	4·3	6·4	11·2
Occupied and retired merchant seamen .	9·6	13·9	19·8	29·6

In reply to a question asked in the House of Commons on March 19, 1919, it was stated that for the three years 1910 to 1912, according to figures supplied by the Registrar-General's office, the death-rate per 1000 for "all males" from 25 to 55 years of age was 24·9, whilst for coal miners it was 20·7.

Nottingham district has been shown to be due to the large admixture of stone dust in the natural dust of the mines. In a number of samples taken from different pits in the Nottingham district, the proportion of stone dust present was found to be about 50 per cent.

The physical effect of inhaling dust is an important question in relation to the health of miners.

Men working in dry and dusty coal mines inhale large quantities of dust without any bad effects ensuing. In fact, as has been shown, coal miners are singularly free from phthisis and lung diseases.

Men working in metal mines, on the other hand, particularly in Cornwall and in the Transvaal, and also in some slate quarries, suffer greatly from lung trouble. The inhalation of large quantities of pure silica in fine particles means certain death in a few years. Dr. Haldane has investigated this matter, and his conclusions are stated in a paper, "The Effects of Dust Inhalation" (*Trans. Inst. Mining Eng.*, June 1918). Certain kinds of dust, such as coal dust and some shale dusts, stimulate the cells of the lungs to get rid of it, so that the dust, or a large proportion of it, is eliminated from the system, and no bad results follow.

But hard siliceous dusts, such as quartz dust, remain in the lungs, which thus soon become overloaded with the dust, and disease is set up.

Moreover, the lungs are rendered particularly susceptible to the tubercle bacillus, and death by phthisis is the usual result.

That the natural dust of coal mines, though containing sometimes considerable quantities of injurious dusts, can be inhaled without serious results is evident from many years of practical experience in collieries. Dr. Haldane's investigation has confirmed this conclusion. Experiments on animals show that some dusts act as scavengers and carry out the dangerous dusts with them. What proportion of the stimulating dust must be present in order to secure immunity has not yet been determined. These experiments had to be postponed owing to the war, and further investigation is very desirable.

Dr. Tatham's investigation enabled him to state as a general conclusion as to the health of coal miners that, "speaking generally, they may be looked upon as a very healthy body of men."

But Dr. Tatham's report deals only with the death-rate. As regards sickness and disease prevalent among miners, some information may be gathered from the returns made under the Workmen's Compensation Act, 1906. Scheduled under this Act are twenty-five industrial diseases, for which compensation has to be paid.

The disease from which miners suffer specially is nystagmus. It was hardly known, or at any rate it was little heard of, before the coming of this Act, but during recent years its increase has been most remarkable. In 1908 the number of cases of it under the Act was 460, and in 1913 no fewer than 4551, an increase of nearly 900 per cent in the six years.

The causes and symptoms of this complaint are still a matter of discussion among medical authorities. The most general symptom is oscillation of the eyeballs. It seems to be mainly a nervous disorder, brought on by overstrain and over-fatigue, aggravated probably by the constrained attitude and also by the deficient light in which miners often work.

It was stated not long ago by a medical man, Dr. Samuel McMurray, ophthalmic surgeon to the Longton Hospital, Stoke-on-Trent, that approximately 20 per cent of all underground workers are found to have evidence of nystagmus, but only 0·29 per cent are incapacitated. A mild attack may not incapacitate a man in any way.

The subject is fully dealt with by Dr. Frank Shufflebotham in his fourth Milroy lecture (March 1914). He states that miners' nystagmus is the most frequent of all occupational diseases.

It is now recognized in all the principal coal-mining countries as a disease affecting the earning capacity of coal miners. It is almost unknown in ironstone and metalliferous mines, and in naked-light pits from which coal is obtained it is very much less frequent than in mines in which safety lamps are used.

It is worth noting too that at several large collieries there has been a marked decrease in the number of cases of nystagmus since the introduction of electric safety lamps in place of oil safety lamps.

Next to "Nystagmus," the occupational disease which causes most disablement amongst miners is "beat knee" —"on acute inflammation in the subcutaneous tissues round the knee-joint." During 1913, there were 1630 new cases of it, and sixty-four continued from the previous year.

These two diseases, together with "beat hand" and "beat elbow," are those which cause most loss of work amongst coal miners.

During 1913 there were 7478 cases of disablement by *disease* in the mining industry, and £113,203 was paid by way of compensation for them.

There were no *fatal* cases due to the scheduled occupational diseases.

Due to *accidents*, there were 195,378 cases of disablement, for which £1,010,637 was paid by way of compensation, and 1312 fatal cases, for which £227,418 was paid to dependants. This applies to the whole mining industry, metal as well as coal mining, but coal mining constitutes within 2 to 3 per cent of the whole.

There has been a steady increase in the number of cases, and in the amount of compensation paid since the Act came into force. Taking the five-year period 1909–13, the official returns under this (Workmen's Compensation) Act show that in the mining industry, whilst the number of persons employed has increased by 13 per cent, the number of disablement cases has risen by 26 per cent, and the total compensation paid, by 36 per cent. No doubt the Act encourages malingering, but this increase cannot all be thus accounted for.

This sad curtailment and mutilation of human life and energy calls for the most earnest efforts of amelioration on the part of all concerned, including the medical profession. Health and strength are predominant factors in human well-being and efficiency.

CHAPTER VIII

SCIENCE

IT is by co-ordinating all the forces in the industrial field so that they may co-operate to the best advantage of the whole that progress and prosperity will be assured. These forces are labour, capital, business ability, technical skill, scientific knowledge and research, trained capacity and efficiency of all workers engaged, whether with brain or hand.

Of all these factors, one of the most, if not the most important, is science, "the mastery of exact knowledge, and man's more accurate control of material forces." "All industrial development tends to become more and more scientific." The help which a trained scientist can give to practical industry is well exemplified by what Dr. Haldane, the Director of the Doncaster coal owners' laboratory, has done for the art of coal mining in connection with explosions and rescue work, and the spontaneous combustion of coal and gob fires.

In the Institution of Mining Engineers, established in 1889, and incorporated by Royal Charter in 1915, the coal-mining industry possesses a valuable organization on its technical and scientific side. The very useful work in the prevention of accidents, and the improvement of mining processes which has been accomplished by the various local Institutes combined in this Federation, since the formation in 1852 of the North of England Institute of Mining and Mechanical Engineers, is not always appreciated as it deserves.

The diminution in mine accidents is sometimes attributed entirely to legislation and inspection, and the very important work of the Institutes in spreading knowledge and stimulating effort is ignored.

Another organization which has done very useful work during recent years is the National Association of Colliery Managers. It has branches in every mining district—thirteen branches in all—and a total membership of 1525 in 1919. Every member must hold a first class colliery manager's certificate of competency. The papers read at its meetings and the discussions thereon are a valuable contribution to mining progress. This Association has been useful, too, in obtaining for colliery management more voice in legislative matters, and in regulations affecting the industry.

The value of deliberate and organized study and investigation is shown in the excellent work of the United States Bureau of Mines. We in England have the experimental station at Eskmeals for research into the nature and prevention of explosions of coal dust and of gas.

It has been proposed that research laboratories, similar to that at Doncaster, should be established, perhaps in connection with the rescue stations, in other mining districts, and no doubt this will be done.

Some of these rescue stations, e.g. those at Chesterfield and Ilkeston, are now being used for mining instruction to classes of students, and they are likely to become useful centres of enlightenment in mining science.

In the Northern Coal-field, the valuable aid which has been given to the industry for many years past, by the professors of the Durham University College of Science, now the Armstrong College, is well known. By his researches into the nature of coal and of coal dust, Dr. P. Phillips Bedson, the Professor of Chemistry, who in 1899 discovered the remarkable solvent action of pyridine on coal, has done much to promote progress, and the recent work of Dr. W. N. Thornton, the Professor of Electrical Engineering, is referred to in Chapter IX.

Coal mining, more perhaps than most industries, calls for the combination of practical experience with scientific knowledge. Progress in the prevention of accidents and in the economical production and utilization of coal depends on the right application in practice of scientific principles and scientific knowledge as distinguished from a blind devotion to custom and reliance on rule of thumb, or doing "what we've always done" so as to avoid the trouble of thinking.

In the appointment of a special committee of the Privy Council to administer a fund for the benefit of the United Kingdom as a whole, with an Advisory Council constituted by Order dated July 28, 1915, the Government took a good step to encourage and organize scientific research and the application of science to industry. This Council with its standing committees, which include a coal-mining committee, should be useful in finding out what is being done in research work, what wants doing, and how it can be best done. Having funds at their disposal, they should be able to extend and to co-ordinate research, and prevent that overlapping and waste of effort which arises from individual workers and individual firms being in ignorance of what is being done by others. A further step was taken by the Government in December 1916, when it established a separate Department of Scientific and Industrial Research for Great Britain and Ireland under the Lord President of the Council, with the President of the Board of Education as Vice-President, an "Imperial Trust for the Encouragement of Scientific and Industrial Research."

In announcing this decision to a deputation of the Board of Scientific Societies, Lord Crewe, as President of the Board of Education, stated, as reported in *The Times* of December 2, 1916, that the Advisory Council and the Coal Committee had agreed upon the beginning of a series of researches which were designed to start, and to establish a scientific basis for, the introduction of a systematic economy in the use of fuel. The intention was to begin with an economical survey of all the various coal measures in the United Kingdom, to examine and experiment on the behaviour of different strata of coal under various furnace tests, and the suitability of different kinds of coal to different processes of coking, and so on.

This was followed in February 1917 by the appointment by the Committee of the Privy Council for Scientific and Industrial Research, on the recommendation of their Advisory Council, of a Board of Fuel Research composed of Sir George Beilby as Director, assisted by Sir Charles Parsons, Mr. Richard Threlfall, and Sir Richard Redmayne, with Professor W. A. Bone as consultant.

In the Education Estimates of 1917–18, issued on March 19, 1917, a "grant in aid" of £1,000,000 was taken to be paid to the account of "The Imperial Trust for the Encouragement of Scientific and Industrial Research."

From this fund grants have been made for investigation into the influence of hot and moist atmosphere on workers in mines, and methods of cooling and drying the atmosphere, and also for an examination of rescue apparatus (see p. 212).

No less important than scientific research is national education. In the coal-mining industry, as in all other industries and departments of human life, the first requirement is for reliable, capable, and well-trained men in all grades. The new Education Act, 1918, is likely in time to make us a better educated people. There can be no doubt of the value, both to the individual and to the community, of an education which develops right character and right social outlook, and which trains and stimulates effort and capacity. As Ruskin said, "The object of true education is not merely to make people do the right thing, but enjoy the right thing."

The provision of mining scholarships for deserving students would promote the efficiency of the industry.

"Mining scholarships should be available to men who have shown special aptitude and ability. Candidates for examination either for first class or second class mining certificates, who have obtained a high percentage of marks, might be encouraged by those scholarships to devote some additional time to special study and investigation before assuming the responsibility of management. The result of this policy over a number of years would be seen in greatly increased interest and efficiency" (Coal Conservation Committee Final Report, 1918).

Something has been done already in this direction. In connection with the South Wales School of Mines there are two scholarships of the value of £40 each, available every year, and tenable for four years. The money for this purpose, and for the maintenance of the school, is given by a number of South Wales colliery companies. They pay a levy of 0·10 of a penny per ton of their output, which provides a sum of about £12,000 yearly.

Again, in connection with the Armstrong College, Newcastle-on-Tyne, there is the "Daglish" Fellowship, provided by the late Mr. John Daglish.

This is tenable for one year, and renewable for a second year under exceptional circumstances. The holder must reside out of the United Kingdom for at least ten months of each year, and during this time he must be engaged continuously in examining and investigating collieries, works, and processes connected with mining. He must also send two reports during each year to the North of England Institute of Mining and Mechanical Engineers on the work he has been occupied upon.

Candidates for the Fellowship must be nominated by the Institute.

At present there is too often opposition, and friction, and misunderstanding between the various elements which conduce to industrial progress. They are working too often in independent and somewhat hostile compartments. The university professor does not always see eye to eye with the captain of industry; the pure scientist has sometimes a lofty contempt for practical industry; and the business man does not always appreciate the value of scientific training and research. But technically trained talent, it has been truly said, will naturally dominate untrained talent in industrial enterprises. Individual rivalries and jealousies between employers sometimes hinder them from co-operating for the general good. The legislator is apt to let the vote colour his view of what is best for the industry. Worst of all, employers and employed are arrayed too often in hostile camps. What is needed is the co-ordination of these various elements so that they may co-operate harmoniously to the benefit of all concerned.

A Ministry of Mines and Minerals, with District Committees, as recommended by the Coal Conservation Committee (Report, 1918), appears to be as good an arrangement as can be devised for exercising the competent control.[1] It is discipline which seems to be our main default, but it may be acquired by training and education.

The difficulty is to reconcile "personal claim" with "organic unity," individual liberty with corporate control. It should be the aim of all who control industrial enterprises to identify the interest of each individual employed with the interests of the whole concern.

The essential principles of a successful use of labour have been tersely summarized by an American manufacturer, Mr. E. C. Gould, as follows:—

1. Get the right man for the job.
2. See that every employee gets a square deal.
3. Make it possible for every man to better himself in the organization.

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[1] The Land Acquisition Committee—chairman, Mr. Leslie Scott, K.C., M.P.—in their Third Report recommend that power should be given to the Mining Department "to supervise the development of coal-fields, and even the production at individual collieries wherever they found that the national interest was being prejudiced, and to make proposals for extension of collieries or amalgamation of collieries, or in the ultimate result for transferring collieries to new lessees, etc."

The Mining Association of Great Britain generally accepts the proposals of the Land Acquisition Committee.

CHAPTER IX

ELECTRICITY

PRECAUTIONS REQUIRED IN ITS USE IN COAL MINES

IN the use of electricity underground the dangers to be met are the risk of igniting gas or coal dust by electric sparks or electric heating, and of electric shock to persons employed. In practice the latter has proved to be the more serious risk.

The Coal Mines Act, 1911, forbids the use of electricity "in any part of a mine where, on account of the risk of explosion of gas or coal dust, it would be dangerous to life," and also enacts that "if at any time in any place in the mine the percentage of inflammable gas in the general body of the air in that place is found to exceed one and a quarter, the electric current shall at once be cut off." The use of electricity in any mine is also subject to a number of stringent regulations issued by the Home Office.

Much attention is being devoted to determining the conditions under which electricity may be safely used underground in coal mines.

Dr. W. M. Thornton, Professor of Electrical Engineering at the Armstrong College, Newcastle, has made it a subject of original research for the last eight years or more, his attention having been first directed to it by the explosion at West Stanley Colliery, Co. Durham, in 1909. He has shown that pit gas (firedamp) is less inflammable than pure methane (CH_4) or than coal (lighting) gas.

Coal gas, i.e., the gas which is commonly supplied for lighting and other household purposes—being much more easily procured than pit gas (firedamp)—is often used in experiment as a substitute for it. Coal gas, for instance, has been generally used in the examination which firemen, examiners, and deputies have to undergo, in order to test their proficiency in detecting the presence of gas by the "cap" showing on the flame of a safety lamp. Coal gas is used also in testing explosives at the Government station at Rotherham. This may lead to the mistaken notion that the two gases are much the same.

The difference between them ought therefore to be clearly recognized. This difference is well brought out in the "Sixth Report of the Explosions in Mines Committee," published in October 1914. At the experimental station at Eskmeals, tests were made with coal gas, with methane (CH_4), and with firedamp brought from Cymmer Colliery, Glamorgan.

The composition of the coal gas and of the firedamp is given as follows:—

	Percentage by Volume.	
	Coal Gas.	Cymmer Firedamp.
Carbon dioxide	0·10	0·90
Ethylene hydrocarbons	3·75	0·20
Carbon monoxide	5·95	0·20
Hydrogen	52·75	nil.
Methane	30·65	96·40
Ethane	3·40	nil.
Nitrogen (by difference)	3·40	2·30
	100·00	100·00

The coal gas contains over 50 per cent of hydrogen and some ethylene compounds and ethane, all of which gases are almost entirely absent from the firedamp. It is not surprising, therefore, that coal gas is much more readily ignitible than firedamp. The presence of 2½ per cent of the coal gas was sufficient to render ignitible a dust mixture, whereas 4·77 per cent—nearly twice as much—of the firedamp was required to ignite the same mixture.

The substitution of coal gas for firedamp may easily lead to wrong conclusions. In fact, it has done so in experiments with gas detectors depending on their action in heating a platinum wire.

Both coal gas and pit gas (firedamp) vary somewhat in their composition, but methane (CH_4) is always the chief constituent of firedamp, forming usually about 90 per cent of it. This is mixed with varying proportions of nitrogen and of carbon dioxide (CO_2)—inert gases, which of course affect its inflammability.

Dr. Thornton has shown that with pure methane the lower limit of inflammability when ignited by electric spark at the open end of a horizontal tube is at 5·6 per cent of it in air by volume at atmospheric temperature and pressure, and the upper limit 14·8 per cent. With a large increase of temperature this lower limit of inflammability falls, but as little as ½ per cent of this gas present in a mixture of coal dust and air increases its liability to be ignited by an electric spark.

The limits of inflammability are wider when the ignition is from the bottom upwards than from the top downwards. As determined by the U.S.A. Bureau of Mines—with ignition from the bottom upwards, the lower limit of propagation of flame is about 4·9 per cent of methane, and the upper limit 15 to 15·4 per cent; but with ignition from the top downwards, these limits become 5·5 per cent to 13·9 per cent (see Technical Paper 119, U.S.A. Bureau of Mines). Dr. Thornton has found that the limits of inflammability of gases vary greatly with the kind of electric spark igniting them, and with the pressure. It is not every spark that will ignite inflammable gas. A rise of 2 inches in the barometer—from 28 inches to 30 inches—somewhat increases the inflammability by impulsive sparks. (See "Influence of Pressure on the Electrical Ignition of Methane," Dr. Thornton, Brit. Association Meeting at Newcastle, 1916.)

Experiments have shown that under increased pressure of the gaseous mixture, the electrical discharge has more difficulty in passing across a fixed spark-gap—not that the mixture is less "ignitible" (see Dr. R. V. Wheeler, *Trans.*

Chemical Society, August 1917)—and an investigation by the U.S.A. Bureau of Mines (see Technical Paper 121, 1917, G. A. Burrell and J. W. Robertson) on the effect of varying pressures and temperatures leads to the conclusion that the low limit of complete inflammation of methane-air mixtures is not changed at pressures as great as five atmospheres. The effect of increased temperature, on the other hand, was clearly shown. At 500° Centigrade the low limit of complete propagation varied from 3·75 to 4 per cent of methane as compared with 5·46 to 5·56 per cent at 25° Centigrade. Increased pressure makes the explosion more violent, though it has little effect on the limits of inflammability.

At ordinary temperatures and pressures in mines there is no danger from the gas alone under about 5 per cent of it in air. The 1¼ per cent of the Government Regulations allows therefore a good margin of safety; this limit is designed to cover risks arising from the presence of dust.

Continuous current is more dangerous than alternating. With continuous current at 100 volts, 8 per cent of methane makes the most inflammable mixture, but with alternating current at 40 periods 200 volts, this proportion is 10·2 per cent; the mixture is extremely sensitive to change of frequency.

Pit gas containing nitrogen requires greater igniting currents than methane.

In lighting circuits, the break of any continuous current may fire gas, but not in general of alternating current at low voltages. Alternating current is also safer in connection with the insulation of electrical currents. Under direct current the insulation is more likely to break down, especially when moisture is present. (See "Insulation under Direct and Alternating Current, particularly as regards Moisture," by Professor Thornton. Address delivered before North of England Branch of the Association of Mining Electrical Engineers.)

The possible danger of electric signalling circuits is a question which was raised by the Senghenydd explosion in South Wales. It was suggested, but not generally accepted, that it might have been caused by sparks from an electrical signalling apparatus.

Dr. Thornton has designed an electrical signalling bell (date of patent, February 3, 1915) for which it is claimed that it is safe in an explosive mixture (see *Trans. Inst. Mining Eng.*, vol. l. part 1).

Independent examination of this bell has confirmed its safety in an explosive mixture. (See Discussion on Battery Signalling Bells by Association of Mining Electrical Engineers (Lancashire, etc., Branch), January 1916.)

The safety of electric signalling with bare wires has been thoroughly investigated at the Eskmeals Experimental Station by Dr. R. V. Wheeler, and two reports have been issued by the Home Office, the first in January 1915, and the second—a joint report by Dr. Wheeler and Professor Thornton—in July 1916. ("Report on Battery Bell Signalling Systems as regards the Danger of Ignition of Firedamp-Air Mixtures by the Break-flash at the Signal Wires," by R. V. Wheeler, 1915; "Report on Electric Signalling with Bare Wires so far as regards the Danger of Ignition of Inflammable Gaseous Mixtures by the Break-flash at the Signal Wires," by R. V. Wheeler and Professor W. M. Thornton, 1916.)

This investigation results in the conclusion that the bare wire system of electrical signalling as commonly employed can be rendered quite secure from any danger of the ignition of inflammable gases by the break-flash at the signal wires or at the contacts of the signalling instruments, and the report shows how this security may be maintained.

As regards the safety of electrical apparatus in coal mines, it has been well summed up by Dr. Thornton as follows: "If the use of electricity is placed under the same controlling conditions everywhere as in naked light mines (considering every electric spark as a naked light), and always regarded as a possible source of ignition unless the parts are completely protected with metallic armouring and covers, all dangers can be met and guarded against. The risks are even now no greater than those attending the use of flame safety lamps."

The great aim to be kept in view in the installation and maintenance of electrical apparatus in a fiery mine is *to prevent the possibility of open sparking.*

Most of the deaths and injuries which have occurred from the use of electricity at coal mines are due not to the igniting of gas, but to electric shock. In 1913 there were only 15 fatal accidents definitely due to electricity, causing 16 deaths, and all of them were caused by electric shock. Of the 53 non-fatal accidents which occurred from the use of electricity at coal mines during the same year, 1913, 50 were due to electric shock, causing injury to 51 persons. Defective earthing and imperfect insulation of cables were the faulty conditions which have given rise to nearly all these accidents.

In his annual report (1914), Mr. Robert Nelson, H.M. Electrical Inspector of Mines, states that during the nine years from January 1, 1905, to December 31, 1913, electric shock below ground has been responsible for 83 recorded accidents and 86 deaths. Of these deaths, very nearly 50 per cent, or half of them, have been due to the absence of—or to an inefficient—earth connection with the outer coverings of electrical apparatus, and 37 per cent of them have been due to defective insulation of cables. The remaining 13 per cent of the 86 deaths are put down to contact with uninsulated live parts and to misadventure. Electric shock has proved to be the chief danger under existing conditions.

" It is not too much to say that the provision of good earths properly connected to every metallic surface with which users may come into contact, means the saving of a considerable number of lives " (see "Earthing Electrical Services in Mines," *Colliery Guardian*, July 12, 1918).

The recent rapid growth of electrical plant at collieries is shown by the fact that during the four years 1909–13 the horse-power of it in use below ground increased by 85 per cent.

A summary of the annual returns, made under the Coal Mines Act, of the aggregate horse-power of electric motors in use above and below ground at coal mines, shows that at January 21, 1913, it amounted to 628,097 H.P.; of this 371,422 H.P. was below ground. In 1916 the total had increased to 850,661 H.P., and in 1917 to 913,640 H.P.

There were 1307 electrically driven coal-cutting machines in use at the end of 1913, and at the end of 1917 the number had increased to 1739. The increase in the use of electric safety lamps has been very marked, the number being 4298 in 1911, 37,823 in 1913, and 146,651 in 1917. The number of flame safety lamps in use in 1917 was 600,919.

During the eleven years 1907 to 1917, the number of persons killed below ground by accidents, due to the use of electricity, has been as follows: 1907, 10; 1908, 12; 1909, 13; 1910, 15; 1911, 9; 1912, 7; 1913, 13; 1914, 4; 1915, 8; 1916, 4; 1917, 2.

Considering the great expansion of electrical plant, the small number of accidents is satisfactory, and their ratio to the horse-power used is clearly decreasing.

CHAPTER X

THE VALUE AND EXTENT OF THE INDUSTRY

FUEL ECONOMY

THE coal-mining industry ministers to the needs of the community by supplying it with an essential commodity which cannot be got without difficulty and danger.

Coal is the natural product from which we chiefly derive those three essential requisites of civilized human life, namely, heat, light, and power.

Before the eighteenth century, coal was used mainly for domestic purposes in the production of *heat*.

With the advent of the steam engine about 1700 A.D., it entered upon a new and much extended career as the generator of *power*.

And a hundred years later—about the beginning of the nineteenth century, it began to be used for its yield of gas in producing *light*. Messrs. Boulton & Watts' Works at Birmingham were lighted by means of coal gas in 1803.

Now at the beginning of the twentieth century we are beginning to realize the value of coal as our chief source of hydrocarbons—such as benzol (C_6H_6), and toluol (C_7H_8), and of oils suitable for driving internal combustion engines, and of ammonia, and of tar with its numerous valuable derivatives.

Coal is one of the necessaries of life, and it enters into the cost of all other necessaries of life. It is the chief raw material of industry.

In the eloquent language of Mr. Lloyd George when

Minister of Munitions, in his speech at the Coal Conference in London on July 29, 1915:

"In times of peace coal is the most important element in the industrial life of the country. The blood which courses through the veins of industry in this country is made of distilled coal. In peace and war, King Coal is the paramount Lord of Industry. It enters into every article of consumption and utility. It is our real international coinage. We buy goods abroad, food, and raw material. We pay, not in gold, but in coal. In war it is life for us, and death for our foes. It not merely fetches and carries for us; it makes the machinery and the material which it transports. It bends, it moulds, it fills the weapons of war."

Stanley Jevons writing in 1865 said of coal:

"It stands in truth not beside, but entirely above, all other commodities. It is the material source of the energies of the country—the universal aid—the factor in everything we do. With coal almost any feat is possible or easy; without it we are thrown back into the laborious poverty of early times."

Coal and coal mining have been intimately associated with the wonderful progress of engineering science and invention during the last two centuries.

Savery's and Newcomen's "fire-engines," and later Boulton & Watts' steam engine, were first used at mines, and the desire to economize in coal has been probably the chief stimulus to the successive improvements in the steam engine which have been going on ever since.

The steam locomotive running on rails had its birth and early development at collieries near Newcastle-on-Tyne in the brains and by the efforts of colliery engineers.

Just as the steam engine was first used for pumping water at mines, so at mines were made some of the earliest applications of electricity in driving underground pumps.

During the present generation the equipment of coal mines has been entirely transformed by the use of electricity, and the electrical engineer is an important member of the staff of a modern colliery.

In considering the importance of the coal-mining industry in this country, we should remember that it gives employment to about a million adult males, and produces and distributes wealth to the amount of over 140 million pounds sterling yearly.

Taking an average family to number five, some five millions of our working-class population are directly dependent on it. And the carriage and distribution of 280 million tons of coal evidently must employ a large number of other persons, and minister largely to the prosperity of our railway and transport trades.

Many other trades and industries, such as agriculture, timber, the machinery and metal trades, derive large support from coal mining.

In 1913, 84,024 horses were employed at collieries, and the breeding and feeding of them must give a good deal of employment to the farming industry.

The total amount of timber consumed annually by British collieries before the war was about 4½ million tons, or, roughly, one cubic foot of timber per ton of coal produced. For most of this we are dependent on other countries.

In 1913, 3,451,328 loads, valued at £4,445,106, or, roughly, £1. 5s. 9d. per load, came from abroad, chiefly from Russia and France. The effect of the war in reducing supplies and raising the price is shown by the fact that during the first three months of the year 1915, 433,786 loads of pit timber were imported, at a value of £676,662, as compared with 477,226 loads valued at £499,092 during the first quarter of 1914, before the commencement of the war.

In the early part of 1916, the price of pit timber was from 300 to 500 per cent greater than it was before the war.

Some idea of the amount of machinery in use at collieries may be gathered from Chapter XVI.

The proper lubrication of machinery is a very important detail in its efficient working, especially in these days of superheated steam and of fast-running turbines and generators, and much oil and grease is used at collieries for this purpose.

Many other things—ropes, chains, rails, pipes, electric cables, bricks, cement, lamps, explosives, etc.—are required for coal mining.

It distributes wealth in many quarters.

Conversely, most industries require coal.

It may indeed be called the bread of industry, as few can exist without it. Industry follows cheap fuel.

Our plentiful supply of coal forms the basis of our industrial and commercial prosperity.

The extent and value of the industry is indicated by the fact that during the forty-one years 1873-1913, 7,940,579,000 tons of coal have been raised in the United Kingdom, of a value at the colliery of £2,950,594,385. Of this total, 1,931,802,000 tons, or about one-quarter, have been sent abroad, in return for the multitude of commodities which we require from other countries.

EXPORT

The export of coal is a very important factor in our Foreign and Shipping trades and in the general prosperity and well-being of the whole community. Coal constitutes in normal times about 80 per cent of our total exports in weight; and 10 per cent in value. In 1912 we transacted over 70 per cent of the whole seaborne coal trade of the world.

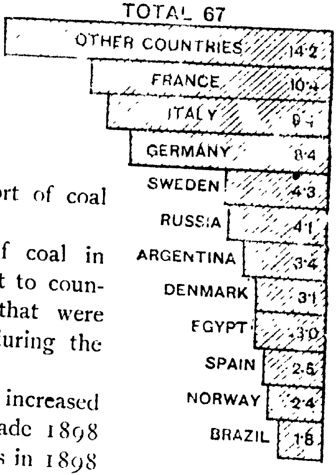
By the coal which we export, we pay to a large extent for our imports from foreign countries.

Stopping our export of coal means stopping our imports of wheat and food-stuffs and timber and iron ore and other things which we get in exchange from abroad.

Most of the coal which we export comes from South Wales and from Northumberland and Scotland.

In 1913, 29,875,916 tons were shipped at Bristol Channel ports—chiefly Welsh coal—and 23,023,810 tons from the Newcastle coal-field at North-Eastern ports. Scotland sent abroad 10,437,197 tons. Of growing importance, owing to the development of the South Yorkshire coal-field, are the Humber ports, which came next with 8,883,358 tons.

In 1913, France took the largest quantity, namely, 12,755,900 tons; Italy took 9,647,161 tons; and our four next best customers were Germany, 8,952,328 tons; South America, 6,892,905 tons; Russia, 5,998,434 tons; and Sweden, 4,563,076 tons. See diagram showing the destination of British export of coal in 1912.



Destination of British Exports in 1912, in millions of tons.

Of our total export of coal in 1913, 33,818,985 tons went to countries or their possessions that were allied with us afterwards during the war.

Our export of coal increased enormously during the decade 1898 to 1907, from 36 million tons in 1898 to 66 millions in 1907, an increase of 83 per cent. But during the succeeding six years—1907–12—it never rose above 67 millions, an increase of less than 2 per cent. In 1913 there was a big jump to 77 million tons.[1]

Expressed as a proportion of the total output, the export for the five-year period 1873–77 was 13·8 per cent, and for the five years 1908–1912, 32·4 per cent. In 1913 it was 34 per cent. The diagram, page 98, shows the dwindling output and export during the subsequent years 1915 and 1917.

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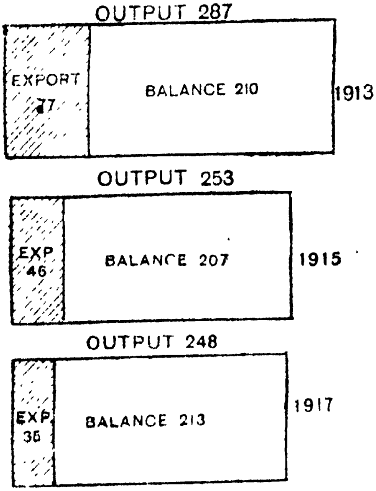
[1] These figures include the export of coke and manufactured fuel, which, however, form only a small proportion—about 4 per cent—of the whole.

The coal exported comes into competition with coal from other countries, and this of course has its effect on the selling price. And the price of the exported coal, which constituted before the war about one-third of the total output, necessarily affects the price of the coal sold for home consumption. The home market is not a closed one, and prices in the home market cannot be raised much above those obtained for exported coal, which is subject to foreign competition.

The average price of coal exported during 1913 was about 13s. 9d. a ton.

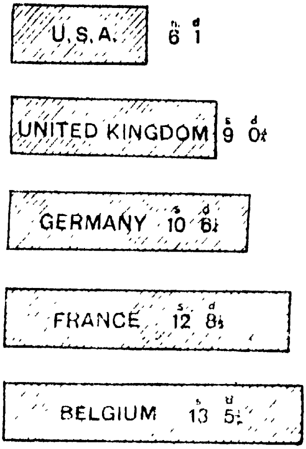


British Output and Export in 1913–17, in millions of tons.

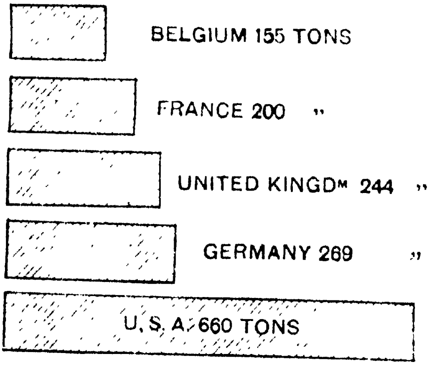
Dealing with the effect of exports of coal on British consumers, the Royal Commission on Coal Supplies in their final report in 1905 point out that "the larger output rendered possible by the export trade enables the collieries to be worked regularly and to the fullest capacity, and that the general and fixed charges being spread over a larger tonnage, the average cost of working and consequently the selling price to the British consumer can be kept lower than would be the case if the collieries were worked for home consumption only."

A Special Committee was appointed by the Board of Trade in June 1916 to consider the position of the coal trade after the war, with special reference to international competition, and to report what measures, if any, are necessary or desirable to safeguard that position.

The first recommendation of their report, which was issued in June 1918, is "That the policy of the country be



VALUE PER TON AT PIT'S MOUTH



OUTPUT PER MAN

directed towards maintaining and, if possible, increasing the export coal trade."

Exception should be made perhaps in the case of coal of special quality, such as high-class coking coal. Much of this coal has been shipped in the past as "bunker" coal, for the use of steamers, which certainly seems to be a wasteful misuse of it.

In 1913, the last full year before the war, the total output of coal was 287,114,869 tons of a value at the colliery of £145,535,669, the average price being 10s. 1·52d. per ton.

Professor Henry Louis has calculated the proportions of the various items making this total price as follows:—

	Per cent.	s.	d.
Wages	62·55	6	4
Materials	16·45	1	8
Administration	7·00	0	8·5
Royalty	5·35	0	6·5
Interest and profit	8·65	0	10·5
	100·00	10	1·5

These figures are given as a rough average applicable to the United Kingdom as a whole. (See "The Economics of Coal Production," by Professor Henry Louis—read December 4, 1917, before London Section of the Society of Chemical Industry.)

OUTPUT AND VALUE OF COAL RAISED IN UNITED KINGDOM DURING 1913, NUMBER OF PERSONS EMPLOYED, AND PRODUCTION PER PERSON EMPLOYED.

	Tons.	Value.	Persons employed.	Production per Person employed.
England	199,911,209	£98,510,746	790,720	253 tons
Wales	44,961,623	26,459,396	188,851	238 ,,
Scotland	42,456,516	20,514,873	147,549	288 ,,
Ireland	82,521	50,654	770	107 ,,
United Kingdom	287,114,869	£145,535,669	1,127,890	255 tons

Judged by the test of production per person employed, Scotland is the most efficient of the four partners. This is probably due mainly to the fact that the Scotch miner works more regularly than the miners in England and Wales.

In the Third Report (September 1916) of the Coal Mining Organization Committee, the percentage of absentees for the four months ended March 31 in the years 1914–15 and *1915–16 is given as follows*:—

	Year 1914–15	Year 1915–16
Scotland	6·3	6·2
Wales	10·3	10·6
England	10·6	10·3
United Kingdom . . .	10·0	9·9

10s. 1·52d. is the highest value per ton since 1900, when it reached 10s. 9¾d.[1] With these two exceptions it has never risen to 10s. per ton during the twenty-five years preceding the war. For the five-year period 1901–5 it averaged 7s. 10¼d., and in 1912 it was 9s. 0¾d. In Germany the price per ton was 10s. 6¼d. in 1912, as compared with 8s. 9½d. the annual average for the five years 1901–05, but in the U.S.A. it has remained much the same, the values being 5s. 10¾d. in 1901–05, and 6s. 1d. in 1912. The largest increase in price has been in Belgium, from 10s. 8¾d. in 1901–5 to 13s. 5½d. in 1912.

It is noticeable that the value per ton at the pit mouth in the five countries, as shown in diagram, page 99, bears generally an inverse ratio to the output per man.

It is the production per person employed that is one of the weightiest factors in determining the cost of the coal at the pit.

It should be borne in mind that the coal produced in these different countries is not all of the same quality.

Of our total output in 1913, 5,194,620 tons were anthracite coal valued at £3,089,847, giving an average price at the pit of 11s. 10·7d. per ton. The great bulk of this, namely, 4,833,159 tons, came from South Wales, and the rest from Scotland and Ireland. About half of it, namely, 2,547,712 tons, were shipped abroad, at an average price at the pit of 16s. 0·9d. per ton. A large portion went to France and Germany to be used for domestic purposes in house stoves.

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[1] The average prices of coal at the pit mouth from 1881 to 1911 inclusive were ascertained or estimated by the Inspectors of Mines, but by enactment of the Coal Mines Act, 1911, the prices for 1912 and 1913 and subsequent years are supplied by the colliery owners.

In considering the cost of coal to the consumer, the cost of transport and of distribution must of course be added to the cost at the pit mouth.

The total quantity of coal sent away from the country in 1913 amounted to 98,338,104 tons, made up as follows:—

£ 53,659,660[1]	Coal exported	73,400,118 tons
	Estimated coal equivalent of coke exported	2,058,508[2] ,,
	Estimated coal equivalent of manufactured fuel exported . . .	1,847,868 ,,
12,894,500	Shipped for use of British and foreign steamers engaged in foreign trade .	21,031,550 ,,
£66,554,160	13s. 9d. a ton Total	98,338,104 tons

The manufactured fuel consists of about 90 per cent of very fine "slack" coal mixed with 10 per cent of pitch. The total quantity made in the United Kingdom during 1913 was 2,213,205 tons valued at £1,895,847. Most of it is made in South Wales, and some in Scotland.

Nearly all of it is exported, the total export in 1913 being 2,053,187 tons. Of this, 573,000 tons went to South America, 496,000 to France, and the rest to Italy and Spain. Most of it is used on railways for the locomotives.

The high price of coal is likely to increase the demand for manufactured fuel or briquettes, and "Briquetting" offers a profitable outlet for the economical utilization of slimes and small coal and coke breeze, which are often wasted.

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[1] This is more than 10 per cent of the total value of the domestic produce exported.

[2] The quantity of coke exported from Great Britain in 1913 was a record, and amounted to 1,235,000 tons.

A test made at Clifton Colliery, Nottingham, of the value of ovoid (or egg-shaped) briquettes as a boiler fuel showed that weight for weight they raised more steam than the coal itself.

Mr. J. A. Yeadon, who has had much experience in this matter, has stated that the actual cost of making briquettes in this country in 1917, including pitch, motive power, steam, and grease, and including 15 per cent for interest on capital and depreciation, was 2s. 9d. per ton for a 50-ton plant. (See *Trans. Inst. of Mining Eng.*, 1917, vol. liii. p. 3.)

The Coal Conservation Committee in their Final Report, August 1918, state:

"A more determined effort should be made to encourage the consumption of patent fuel in the United Kingdom, both for steam-raising and domestic purposes, thereby achieving two objects: (1) inducing colliery owners to bring to bank more of the small coal; and (2) setting free for export a greater quantity of large coal, which, by reason of its higher price, is better able to bear heavy freights and meet German and American competition in oversea markets."

HOME CONSUMPTION

Deducting the coal exported, the quantity left for home consumption in 1913 was 189,092,369 tons. This is equivalent to 4·108 tons per head of population. It is the highest on record, with the exception of the year 1907, when it amounted to 4·176 tons per head.

It was 3·66 tons for the five-year period 1886–90, and 4·04 tons for the five years 1906 to 1910.

This increasing call for fuel would seem to be a symptom of continued industrial expansion and prosperity.

The United States is the only country which surpasses Great Britain in the coal consumed in proportion to the population.

The diagram, page 105, shows the relative total consumption of coal of the countries specified during the year 1912.

How the home consumption is used is a matter of considerable interest.

The Royal Commission on Coal Supplies in their Final Report in 1905 gave the following figures as approximately correct for the year 1903, being based on information collected from many sources. It is still the most reliable statement available, and the relative proportion of coal consumed under the different heads, which is shown here in percentages, probably remains much the same in normal years.

HOME CONSUMPTION OF COAL IN UNITED KINGDOM IN 1903.

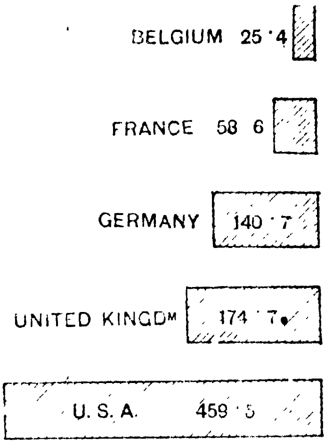
	Tons.	Per cent.
Factories	53,000,000	32
Mines	18,000,000	11
Domestic	32,000,000	19
Iron and steel industries	28,000,000	17
Other metals and minerals	1,000,000	
Gas Works	15,000,000	9
Railways (all purposes)	13,000,000	8
Brick works, potteries, glass works, chemical works	5,000,000	3
Coasting steamers (bunkers)	2,000,000	1
Total	167,000,000	100

The lower diagram, page 105, which is taken from the *Times Trade Supplement* of November 1918, shows the estimated home consumption for 1913.

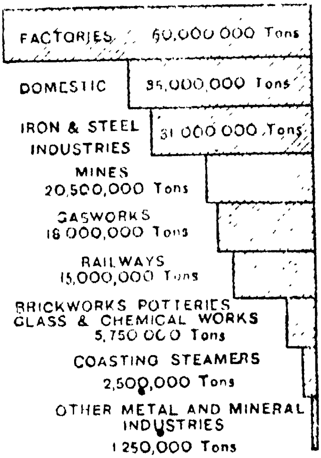
The Royal Commission in their Report of 1905 draw special attention to the interesting calculation made by Dr. George Beilby, that out of this annual consumption of 167 million tons there is a possible saving of about 60 million tons.

Of the 71 million tons used in factories and mines, it was estimated that 52 millions were employed in steam raising. This is equivalent to a consumption of 5 lb. of coal per horse-power hour. With the increasing use of electricity for generating power which has taken place since 1903, the average fuel consumption is no doubt below this figure now.

"In a census taken in 1916 of four groups comprising 26 electrical undertakings in Lancashire and Cheshire ranging in capacity from 500 K.W. up to 90,000 K.W., it was found that the consumption of coal varied from 2½ lb. to 8 lb. per Kelvin (K.W. hour) sold, the average consumption of all the undertakings in the groups (including the largest municipal undertaking in Britain) being 3·2 lb. This figure is equal to 2·4 lb. per horse-power hour." (See paper on "Fuel Economy" by Mr. J. A. Robertson, Borough Electrical Engineer of Salford. Read before Incorporated Association of Municipal Engineers, June 1917.)



Coal consumption in millions of tons in 1912.



Home coal consumption (estimated).

With the best modern steam turbines, it is possible to get a horse-power hour for a consumption of 1 lb. of coal. A 35,000 H.P. Parsons' turbo-alternator recently installed at Chicago has achieved on its trials this low consumption of 1 lb. per horse-power hour. Thus, by the adoption of the most efficient engines, a large saving of coal may be effected.

Again, there is a large margin for economy in the 19 per cent consumed for domestic purposes. Our present methods of burning coal in open grates are extremely wasteful. Millions of gallons of benzol and other valuable products are thus lost. Most of the coal thus wastefully used could be treated so as to produce per ton about 12 cwt. of a semi-coke which will burn with a luminous smokeless flame, giving out more heat in the domestic grate, and at the same time the much-needed benzol, ammonia, and tar would be recovered, see page 123.

Some who have tried a semi-coke of this description prefer it to ordinary coal. Dr. Dunn, the city analyst of Newcastle-on-Tyne, has stated that after a month's use of a smokeless fuel of the coalite type, produced by low temperature distillation, he found that it entailed far less labour; no cleaning of the flues was necessary; it was more under control, and in every way, quite apart from producing no smoke, was preferable to coal. (See Newcastle Section of Society of Chemical Industry. Discussion on paper by Professor Henry E. Armstrong, February 1916.)

"Why should not the use of semi-coke, where solid fuel is required, become universal? Such a revolution would make England independent of foreign countries for her liquid fuel supply, would settle the smoke problem, and would effect an economy in industrial fuel consumption which might double her prosperity." (See *Times Engineering Supplement*, April 30, 1913.)

Again, as regards the coal used in the iron and steel industries, Dr. Wm. A. Bone has stated that if these industries were organized on the best possible plan—namely, brought together on one site—by-product plant, coke ovens, blast-furnaces, and steel-works—the total consumption of fuel, instead of being 30 million tons of coal —the figure for 1913—ought not to be more than from 15 to 20 million tons. Experience at the Skinningrove Iron Co.'s works has led to the conclusion that it will soon be possible to make finished steel rails or girders from Cleveland ironstone with no further consumption of coal than is charged into the by-product coke ovens for the production of the coke required for the blast-furnace. (See Professor Bone's Presidential Address before the Chemical Section of the British Association, September 1915.) At this company's steel-works, the fuel consumption per ton of steel produced has been reduced from 2·35 to 1·6 tons of coal.[1]

The possible economy that may be effected in the carbonization of coal in coke ovens is considered in Chapter XIII.

It may be stated with confidence that it is possible to produce the same amount of power and heat as at present with a consumption of from 30 to 40 per cent less coal. Putting it at 35 per cent, this would mean—on the 189 million tons of home consumption in 1913—a saving of 66 million tons.

Is there any economical question of greater national importance than the proper utilization of our coal?

"If power supply in the United Kingdom were dealt with over comprehensive lines, and advantage taken of the most modern engineering developments, the saving in coal throughout the country would, in the near future, amount to 55,000,000 tons annually on the present output of manufactured products," apart from possible saving on domestic coal consumption. (See Report, 1918, of Coal Conservation Committee.)

Taking our consumption of coal for domestic purposes at 30 million tons, and for industrial purposes at 70 million tons, Mr. F. D. Marshall, a past-president of the Institute of Gas Engineers, has estimated the loss arising from our wasteful methods of using the coal to be £134,000,000 annually! (See *Iron and Coal Trade Review*, 28th February 1919.)

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[1] This matter of Fuel Economy in Steel Works is ably treated by Mr. Benjamin Talbot in an Appendix to the Final Report of the Coal Conservation Committee (1918).

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The following figures show the estimated quantities of coal remaining in proved coal-fields at depths not exceeding 4000 feet and in seams not less than 1 foot thick:—

	Millions of Tons.
South Wales and Monmouthshire	26,471
Somersetshire and part of Gloucestershire	4,198
Forest of Dean	259
North Staffordshire	4,368
South ,,	1,415
Warwickshire	1,127
Leicestershire	1,825
Shropshire	321
North Wales	1,736
Cheshire	292
Lancashire	4,239
Yorkshire	19,1[illegible]3
Derbyshire and Nottinghamshire	7,361
Durham	5,271
Northumberland	5,510
Cumberland	1,528
Scotland	15,681
Ireland	174
	100,914

South Wales and Yorkshire are much the wealthiest districts in their reserve supplies of coal.

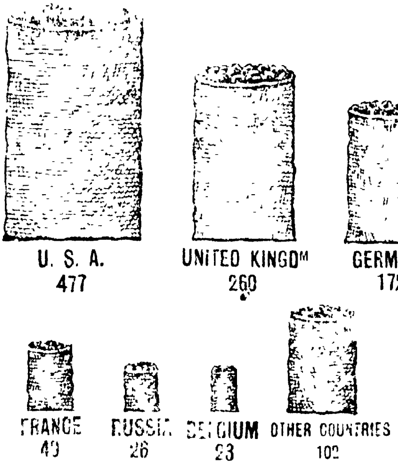
The tendency of successive inquiries has been to discover new sources of supply.

At the International Geological Congress held at Toronto in 1913, the coal resources of the world was made the principal subject of investigation. The conclusion reached as regards the United Kingdom was that the total coal reserve amounts to 186,487 million tons, which is a considerable increase on the above estimate of 1905. Of this total, 139,225 million tons are "Estimated Actual Reserves," and 47,261 million tons "Estimated Probable and Possible Reserves" (see official Coal Tables, 1912). Of the total coal reserves of the world, it was estimated that only 2·6 per cent is in Great Britain, and only 23·5 per cent, i.e., less than one-fourth, in the whole British Empire.

RELATIVE POSITION OF UNITED KINGDOM TO OTHER COUNTRIES

"The total known coal production of the world in 1912, exclusive of brown coal or lignite, was about 1100 million English tons"[1] (see Coal Tables, 1912, the last published). In 1913 it was 1250 million tons, in 1903 800 millions.

The United States is much the largest coal producer, contributing in 1912 477 million tons (of 2240 lb.). The United Kingdom was second with 260 million tons, and next came Germany with 172 million tons. These three countries produced together over 900 million tons, or about 80 per cent of the whole output of the world. In 1913 their contribution rose to 83 per cent. No other country comes near them. See diagrams.



World's coal production in millions of tons in 1912.

Per head of the population, the United Kingdom produces more than any other country, the figures for 1911 of the first four countries being United Kingdom, 6·00 tons; United States, 4·73 tons; Belgium, 3·02 tons; German Empire, 2·38 tons.

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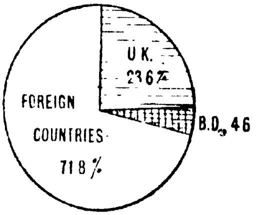
[1] The English ton is 2240 lb., or the "long" ton. In the United States, and in some of our British Dominions, a "short" ton of 2000 lb. is used. There is also a "metric" ton equal to 1000 kilogrammes or 2204·6 lb.

The United Kingdom is also much the largest exporter of coal, the figures for 1912 being United Kingdom, 67 million tons; Germany, 42½ million tons; U.S.A., 7¼ million tons. But the production of coal per person employed in the industry is much less in the United Kingdom than in the other two countries. In 1912 it was 660 tons per person employed in the U.S.A.; 269 tons in Germany; and 244 tons in the United Kingdom.

There has been a steady decrease in the United Kingdom in recent years, from 292 tons in 1906 and 1907 to 271 tons in 1908; 266 tons in 1909; and 260 tons in 1911. In the U.S.A., on the contrary, the output per person employed has been increasing considerably.



TOTAL . .	1,100,000,000	TONS
UNITED KINGDOM	260,000,000	,,
BRIT. DOMINIONS	50,000,000	,,

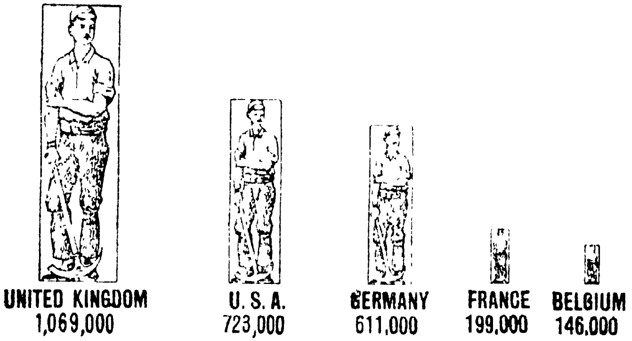
Coal production of United Kingdom and British Dominions relatively to the production of the whole world in 1912.

Though our output is so much less than that of the U.S.A., yet we employ more men than they do, or than any other country. The persons employed in 1912 were, in United Kingdom, 1,069,000; U.S.A., 723,000; Germany, 611,000. (See "Coal Tables, 1912." The figure for Germany represents only the number subject to accident insurance; the total number is assumed to be greater by 5 per cent, making it 641,550.) See diagram, page 112.

The total number of men engaged in coal mining throughout the world has been put at 3,800,000.

In considering the relative position of the United Kingdom, it should be remembered that forty years ago it occupied the premier position, contributing more than one-half of the world's supply. In 1875 the total production of the world was 260 million tons—less than the production of the United Kingdom alone in 1913. Of this total, the United Kingdom produced 133 million; the U.S.A., 46 million; and Germany, 37 million tons.

In the thirty-seven years—1875 to 1912—the coal production of the world has increased more than fourfold; of the U.S.A., more than tenfold; of Germany, about sevenfold; and of the United Kingdom barely twofold.



Persons employed in 1912.

"In its industrial competition with other nations, Great Britain no longer possesses the advantage of a monopoly of cheap fuel. The time may come when we shall be unable to raise coal sufficient for our industries at a price which will enable us to compete in the world's markets. We may become dependent on our competitors for our motive power" (*Times Engineering Supplement*, April 30, 1913).

N.B.—The illustrations are taken from *The Times Trade Supplement*, January 1917.

CHAPTER XII

COAL—ITS COMPOSITION AND CLASSIFICATION

COAL is one of the most familiar of substances, but to define what it is has puzzled our law courts. There is no satisfactory definition. Two facts about it are well established—that it has been formed from vegetable matter, and that carbon is its chief constituent—but " the subtlety and complexity of the substances present in coal is beyond present technique to unravel."

The late Professor Vivian B. Lewes has described it as " An agglomerate of the solid degradation products of vegetable decay, together with such of the original bodies as had resisted to a greater extent the actions to which it had been subjected."

" It has been proved that all coals are conglomerates of two main types of compounds, the one type derived from the celluloses or woody fibre of the plants that formed the coal, and the other type from the resins and gums that formed the sap of the coal plants.

" Coals apparently differ in character according to the proportions that they contain of these two types of compounds, which may be briefly classified as cellulose or 'humic' compounds and resinous substances."

The distinctive properties of these two classes of substances have been stated as follows:—

" Humic " compounds are infusible, yield very small quantities of liquid products on being heated, and are insoluble in chloroform.

Resinous substances fuse at a low temperature; yield a large proportion of liquid products on distillation; are soluble in chloroform, phenol, pyridine, and other solvents;

leave on heating to 500° a pitch which acts as a binding constituent in the formation of coke. (See " Some Aspects of the Low Temperature Carbonisation of Coal," by Edgar C. Evans, B.Sc., F.I.C., Society of Chemical Industry, July 1918.)

In their monograph on " The Constitution of Coal," published in June 1918, Drs. Marie C. Stopes and R. V. Wheeler suggest as a definition of coal in simple terms, " Ordinary coal is a compact, stratified mass of 'mummified' plants (which have in part suffered arrested decay to varying degrees of completeness), free from all save a very low percentage of other matter."

Where there is present a considerable proportion of other matter (mineral detritus, etc.), the substance is not a true coal.

The ordinary householder soon learns from his experience of the domestic fire that coal is a substance which varies a good deal in its properties.

In its hardness and colour and weight, in its readiness to take fire, in the heat and the flame it produces, in its duration of burning, and in the nature and amount of the ash or residue left, there is much variety. It is not a definite chemical compound. Combined with varying proportions of carbon are hydrogen, oxygen, nitrogen, and sulphur, with sometimes phosphorus and arsenic in minute quantities.

There is present also mineral matter of various kinds, chiefly silica and alumina, which forms the "ash" that is left when the coal is burnt. The quantity of ash present, and whether it forms a hard clinker, or not, much affects the value of a coal.

Again, different kinds of coal contain varying proportions of water. This water is not chemically combined with the coal, but is inherent in it, so that it cannot be removed by ordinary drying processes, which remove the superficial water.

The removal of this inherent water depends on its vapour pressure being greater than that of the surrounding atmosphere. (See U.S.A. Bureau of Mines Technical Paper No. 113; Messrs. Horace Porter and O. C. Ralston.)

The water remains inherent in the coal so long as its vapour pressure is less than the vapour pressure of the surrounding atmosphere.

"The first products of decomposition of coal are always water and the oxides of carbon."

In the relative proportions of its constituents, coal presents an endless series of combinations.

The suitability of a coal for any given purpose, e.g., domestic heating, or steam raising, or gas manufacture, or coke making, cannot be determined altogether by chemical analysis. There are other properties, at present not clearly known, which affect the result. A practical trial on a large scale is the surest test.

The same coal seam will yield sometimes different qualities of coal in different layers of its vertical section, and also in adjoining horizontal areas.

There is very little difference in the ultimate analysis of many of the best steam coals and the best gas and coking coals; e.g., below are the analyses of one of the best Durham gas coals, and one of the best North Country steam coals, and of some Welsh steam coals.

Lignite.		Gas Coal.	Steam Coals.			
		Durham.	North Country.	South Wales.		
					High Moisture.	Low Moisture.
50·6	Carbon	82·58	81·00	82·01	74·56	80·74
4·9	Hydrogen	4·42	5·09	4·89	4·91	5·11
20·5	Oxygen	6·64	5·48	5·93	8·20	6·83
	Nitrogen	0·85	1·62	1·00	0·79	1·29
0·6	Sulphur	0·81	1·14	1·11	1·67	1·02
5·5	Ash	3·47	4·12	3·12	3·72	3·08
17·9	Water	1·23	1·55	1·04	6·06	1·93
100·00		100·00	100.00	100·00	100·00	100·00
	Calories		8055	8154	7409	7992

An ultimate analysis of lignite is added on the left.

There can be little doubt that coal and coal seams have been formed in different ways.

Sometimes the vegetation has grown and decayed on the site where the coal seam is now found; sometimes the fallen vegetation has been carried away by streams and rivers, and deposited in lakes and estuaries, and there converted into coal.

There has been a good deal of difference in the parent substance, and in the manner and process of its conversion into coal. Coal seams will vary in quality according to the kind of vegetation which prevailed at the time of their formation. Different plants yield different products. Latterly new light has been thrown on the subject by the microscopical examination of coal.[1]

By his admirable development of this line of research Mr. James Lomax has added materially to our knowledge of the subject. He has shown the various kinds of vegetable matter which enter into the composition of the many coals he has examined, and, by his preparation and examination of continuous blocks of the full section of a seam he has brought useful evidence to bear on the manner of its formation. The results of his work may be studied in a series of papers which he has contributed to recent volumes of the *Trans. Inst. Mining Engineers.*

Microscopical examination is a valuable aid to chemical analysis in determining for what purpose any given coal is best adapted. A scientific classification of coal and coal seams is a very large and complex problem, which calls for the co-operative research of the geologist, the chemist, the botanist, and the microscopist. This is now generally recognized, and no doubt in the near future we shall learn a good deal more about coal than we know now.

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[1] An instructive paper on the "Micro-Petrology of Coal," by Dr. G. Hickling, will be found in *Trans. Inst. Mining Eng.*, May 1917, vol. liii. The monograph (1918) on the "Constitution of Coal," by Drs. Marie C. Stopes and R. V. Wheeler, contains an historical summary of the microscopical evidence bearing on the constitution of coal from 1833 to the present time.

Roughly, for practical purposes, coal may be divided into four main classes—lignites, cannels, bituminous, and anthracite.

Lignites get their name from their pronounced woody structure (Latin *lignum*). They contain much more moisture than other kinds of coal, which reduces their value for heating purposes. Large quantities of lignite are produced in Germany and Austria and Hungary, but the home production of it is limited to Ireland, where the total output in 1913 was only 81 tons.

Cannel (or candle) coal—so called from the bright light it gives when burning—is easily identified by its jet-like appearance, its hard, smooth texture—it does not soil the fingers—and by its conchoidal fracture. It is much in demand for the making of gas, as on distillation it gives off a large quantity of gas of high illuminating power. There is not a great deal of it in this country. Lancashire and Scotland are our chief sources of supply.

It is generally recognized that cannels have been formed from a dissimilar parent substance and under different conditions from bituminous coals.

"Whereas the bituminous coals have probably been formed from various types of vegetation which either grew where now the coal seam is found or were accumulated by drifting from a distance, the sapropelic (cannel) coals are largely made up of the spores of plants embedded in a structureless mass, which is apparently the fossilized remains of the gelatinous slime (sapropel) that accumulates on the surface and bottom of lakes."

Cannels are sometimes spoken of as "spore" coals. They have been coming into increasing prominence lately, owing to the large quantity of valuable oils which can be obtained from them by process of low temperature carbonization. A committee appointed by the Institution of Petroleum Technologists to investigate this subject reported (July 1918) that a large amount of cannel coal and allied minerals suitable for the production of oil is available in Great Britain.

A yield of between 15 and 80 gallons of crude oil per ton can be obtained, and this can be refined to give about 8 per cent of spirit and 40 to 50 per cent of fuel oil. Much of this material is at present a waste product at collieries, either thrown back into the "goaf," or forming unsightly heaps when brought to the surface, and its utilization would be a great step in advance.

The following are typical analyses of a Lancashire cannel and of a good Durham gas coal, showing by comparison the large volume of gas of high illuminating power yielded by the former.

Durham Gas Coal.		Lancashire Cannel.
11,000	Illuminating gas expressed in cubic feet per ton	14,500
16·17	Illuminating power of the gas expressed in standard sperm candles	31
30·3 per cent.	Volatile matters	55·7 per cent.
69·7 ,,	Coke	44·3 ,,
	Ash in coke	6·0 ,,
5·7 ,,	Ash in coal	2·66 ,,
1·7 ,,	Sulphur	0·89 ,,
1·2 ,,	Moisture	0·9 ,,

Figures have been published (see *Iron and Coal Trades Review*, 19th November 1915) giving the average of the amount and composition of the gases from 51 samples of the principal German gas coals, the investigation having been conducted by Mr. F. Hofmann. The average total yield of gas from 100 kilogrammes (=220 lb.) of pure coal treated by dry distillation was 33·44 cubic metres = 1180·9 cubic feet.

The composition of this was as follows:—

		Cub. Ft.	Per cent.
Hydrogen	H_2	642·71	55
Methane	CH_4	356·32	30
Carbonic oxide	CO	115·83	10
Hydrocarbons	C_nH_{2n}	39·19	3
Carbonic acid	CO_2	26·84	2
		1180·90	100

This yield of gas is equivalent to 12,024 cubic feet per ton of coal.[1]

The great bulk of our British coal belongs to the bituminous class, which is far the most important. It covers house, furnace, gas, and coking coal.

The term bituminous is too well established to be altered, but there is no bitumen in coal. The term is used to cover all coal which contains a considerable proportion of resin-like bodies and which when heated to a moderate temperature below that of combustion softens and fuses into a caked mass. The resulting coke may or may not be suitable for metallurgical purposes.

Bitumen has been defined by the Engineering Standards Committee in their Report (No. 76, issued May 1916) on Standard Nomenclature of Tars, Pitches, Bitumens, and Asphalts, etc., as "a generic term for a group of hydrocarbon products soluble in carbon disulphide, which either occur in nature or are obtained by the evaporation of asphaltic oils. The term shall not include residues from paraffin oils or coal-tar products."

The best coal for steam-raising purposes, such as the South Wales and the Northumberland steam coals, comes between bituminous and anthracite proper, and is sometimes classed as semi-bituminous or semi-anthracite.

Anthracite is the kind of coal which comes nearest to pure carbon, containing about 90 per cent of it. It is difficult to ignite, gives out great heat, and burns with hardly any flame, and no smoke. There are extensive deposits of it in South Wales, and some in Scotland and Ireland. It is used mostly for drying malt and hops, for heating house stoves, and for making "suction gas" in gas producers.

Below are four analyses of anthracite from different seams of it in South Wales, made at the Federal Fuel-testing Station at Zurich under the supervision of Professor Dr. Constam.

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[1] In the Household Fuel and Lighting Order of July 1918, 15,000 cubic feet of gas were taken as equivalent to one ton of fuel for heating purposes,

ANALYSES OF ANTHRACITE FROM FOUR DIFFERENT SEAMS OF IT IN SOUTH WALES.

Smokeless Steam Coal.		Per cent.	Per cent.	Per cent.	Per cent.
89·49	Carbon	91·10	90·72	91·47	88·99
4·00	Hydrogen	3·21	3·13	3·11	3·18
3·78	Nitrogen and oxygen	2·10	2·71	2·35	2·64
0·84	Sulphur	·02	·74	·02	·84
1·89	Ash	·83	1·32	·06	3.20
	Water	1·66	1·38	1·10	1·06
Heating capacity in calories [1]		8541	8557	8558	8576

Dr. E. J. Constam writes about these samples of anthracite: "The results of the calorimetric determinations as well as those of the elementary analyses show that the four samples are practically equal, being a high-class anthracite with an exceptionally low amount of non-combustible matter (ash)."

For the purpose of comparison there is given also an analysis of the Welsh Smokeless Steam Coal known as "Hills Plymouth Merthyr," which is on the lists of the British, French, Italian, and Spanish Governments.

Coals containing a large proportion of carbon, like anthracite and smokeless steam coal, are more difficult to ignite, but give out more heat when ignited.

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[1] The calorie is the quantity of heat required to raise the temperature of 1 kilogramme of water through 1° Centigrade. The heating capacity of a coal being 8000 calories, means that 1 kilogramme of the coal will raise the temperature of 8000 kilogrammes of water through 1° Centigrade. Calories multiplied by 3·968 = British thermal units.

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feet of gas and 9 gallons of tar (see Fuel Number, *Times* December 1, 1913). The composition of the resulting gas is of course different. At the higher temperature it contains about twice as much hydrogen and half as much hydrocarbons as at the lower temperature. From about 750° to 900° C., hydrogen becomes the main product of distillation.

Mr. F. D. Marshall (Past-President Inst. of Gas Engineers) has stated the different results obtained by high and low temperature carbonization as follows: " An average coal when submitted to a temperature in the retorts of some 2000° to 2200° Fahr. will yield approximately per ton: gas, 12,000 to 13,000 cubic feet of approximately 500 British thermal units; coke residue, 66 per cent; tar, 9 to 10 gallons; sulphate of ammonia, 20 to 28 lb. A coal of similar character submitted to a temperature of 900° to 1000° Fahr. will yield per ton: gas, 4000 to 6000 cubic feet of approximately 650 British thermal units; coke, 70 to 75 per cent; tar oils, 18 to 22 gallons; sulphate of ammonia, 15 to 22 lb." (*Iron and Coal Trades Review*, February 28, 1919.)

By low-temperature processes much inferior coal—bastard coals and carboniferous shales, hitherto regarded as worthless—may be utilized to yield valuable products.

The products obtained and their quantity per ton of coal are shown in the following figures which have been published by Mr. J. Drummond Paton. They are the average results of a great number of trials on a commercial scale, extending over many years, of coals of many kinds:—

	Bituminous Coal.	Cannels.	Lignite.
Motor spirit	2 to 3 gals.	5 to 9 gals.	2 gals.
Middle oils	4 to 5 ,,	13 to 14 ,,	4 to 5 ,,
Heavy oils	6 to 7 ,,	28 to 30 ,,	7 to 8 ,,
Pitch	25 to 30 ,,	2·05 cwt.	0·8 cwt.
Sulphate of ammonia	23 lb.	21·8 lb.	18·5 lb.
Fuel	15 cwt.	10 cwt.	15 cwt.

Low-temperature carbonization has not yet been established on a commercial scale, but much has already been done in this direction. There can be little doubt about its successful development in the future, bearing in mind that besides yielding a fuel suitable for domestic purposes,[1] by-products are obtained which are of a greater value than those got by coke and gas manufacturers.

It is worth noting that the volume of the smokeless fuel or semi-coke produced is much greater than that of the coal used.

In the low-temperature process of carbonization the coke expands more and contains larger cell cavities and is more porous and friable than the coke made at a high temperature for metallurgical purposes. But this expansion and friability may be modified or prevented by the construction of the retort in which the coke is made.

"It must be confined in comparatively narrow chambers, and the walls of the chambers must be stout enough to withstand considerable pressure" (F. D. Marshall).

Dr. Mollwo Perkin has borne testimony to the good results obtained with the Tozer retort: "With regard to the friability of smokeless fuel he had recently had a consignment from the Tozer-Marshall works, which had been three weeks on the railway in frosty weather, and it only contained about 10 per cent of breeze, and even this was not wasted, because it could readily be briquetted." (*Journal of Society of Chemical Industry*, July 31, 1918.)

With respect to the suitability of this low temperature coke for domestic purposes, Mr. Marshall states that it contains from 9 to 12 per cent of volatile matter which makes it easily ignitible and quite easy to burn in an open grate. Its calorific value is 13,300 B.Th.U. as compared with 14,200 B.Th.U. of coal, but its radiant heat value is approximately double that of ordinary coal, and it makes a splendid fire.

The investigation of this important question of low-temperature carbonization has been undertaken by the Fuel

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[1] See p. 106.

Research Board under the directorship of Sir George Beilby.

In October 1917 a Research Station was instituted on a site next the East Greenwich Gas Works with a view to determining whether an economical apparatus can be designed for the low-temperature carbonization of coal, so as to yield products of a collective value greater than that of the original coal plus the cost of carbonization and handling.

Interesting results have been obtained at an experimental plant erected by the Glasgow Corporation at their Port Dundas Electricity Station in 1916. The object of the Corporation was to find a process of getting smokeless fuel as a by-product of gas manufacture, which shall be economically satisfactory. This plant has been designed and the experiments have been carried out by Mr. Robert Maclaurin. The coal is heated at a low temperature, starting from normal and rising to about 700° Centigrade during a period of about twenty hours, not by external heat, but by contact with the hot gases from a gas producer which forms part of the plant. The quantity of heat thus required to carbonize the coal is very small. One and a half cwt. to 2 cwt. of coal, converted into producer gas, have been found to furnish sufficient heat to convert 1 ton of coal into a hard fuel, which is easily kindled, and burns with a smokeless flame, while a quantity of oil is obtained, and some ammonia is got also. Nearly all the volatile matter of the coal is secured in the form of oil and liquor, and only a little gas, and that of low illuminating value, is given off from the coal carbonized. The oils are trapped before they can trickle down into the hotter regions where they would suffer decomposition, and the absence of this decomposition accounts for the want of light illuminating hydrocarbons in the gas, and for the presence of resinous bodies in the oil.

A special feature of the process in this Maclaurin plant is the limited decomposition to which the coal products are exposed.

The capital cost of the plant (on a pre-war basis) for handling 1 ton of coal per hour, including scrubbers and blowers, is stated to be about £1000, exclusive of coal crushers, elevators, and driving engine.

Speaking about this Maclaurin process (in June 1917, in a discussion on a paper on "Fuel Economy" read by Mr. J. A. Robertson before the Incorporated Association of Municipal Engineers), Bailie Smith of Glasgow stated that 20 tons of coal were carbonized per day.

A low grade of coal can be utilized, but the products obtained depend of course to a considerable extent on the quality of the coal carbonized.

From each ton of coal there was got, on an average, about 13 cwt. of smokeless fuel; 16 gallons of a liquid which could be sold at present for 3d. a gallon = 4s.; 30 to 50 lb. of sulphate of ammonia, worth at present 4s. to 6s., and 12,000 cubic feet of gas of a heating capacity of 300 British thermal units.

The plant can be used either for making smokeless fuel or for producing gas for power purposes, and thus can be kept running at full load for the twenty-four hours. The gas is uniform in quality and free from stringy tar.

In a paper read before the Glasgow Section of the Society of Chemical Industry (July 1917), Mr. Maclaurin states that the most interesting results on the chemical side are: (1) The small quantity of hot gas required to carbonize a ton of coal; (2) the small percentage of light olefines present in the gas; (3) the relative absence of light portions—benzene homologues, carbolic and cresylic acids—in the crude oil; (4) the presence of resinous substances in the oil; (5) the lubricating quality of the non-resinous oil; (6) the drying properties of the crude oil; (7) the presence of dyes in the ammonia liquor and the oil.

AMMONIA

Besides the hydrocarbons, another product which is in much demand is Ammonia. Coal contains on an average about 1 per cent of nitrogen, and this in combination with the hydrogen forms Ammonia (NH_3). By treatment with sulphuric acid the ammonia is converted into Ammonium Sulphate $(NH_4)_2SO_4$, which is a valuable fertilizer of the soil.[1] Approximately 25 lb. of ammonium sulphate can be obtained from each ton of coal carbonized in by-product ovens.

Dr. W. A. Bone has stated that a much larger quantity of ammonia may be derived from the nitrogen in coal by gasifying it in a generator of the Mond type in a superheated air blast saturated with steam at 85° C. than in by-product coking ovens or in gas works. By such means, as much as 80 to 90 lb. of ammonium sulphate may be recovered per ton of a suitable coal, together with about 150,000 cubic feet of gas. (See Lecture by Professor Bone before the Royal Institution of Great Britain, January 1916.)

COKE

Coke is a term which, like coal, covers substances of varying composition and properties. The soft friable coke which is a by-product of the manufacture of lighting gas is different from the hard cellular coke which is made in coke ovens.

The output of iron from a blast furnace depends to a large extent on the hardness of the coke used. A difference of over 20 per cent in the output has been found in some instances to be due to the varying hardness of the coke. (See paper by G. D. Cochrane, "The Importance of Coke Hardness," *Trans. Iron and Steel Inst.*, May 1918.)

For reducing iron ores in the blast furnace, coke needs to be strong enough to withstand the weight and the grinding action to which it is exposed, and it should be of a cellular structure so as to afford a large surface to be acted on by oxygen in order to produce the high temperature required in the blast furnace. The less sulphur it contains the better, as sulphur spoils the iron.

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[1] The growing demand for this substance and the rapid development of the by-product coking industry is apparent from the fact that in the year 1903 the quantity of it thus produced was 17,435 tons, and in 1913 it had grown to 133,816 tons. At gas works during the same years 149,489 tons and 182,180 tons respectively of ammonium sulphate were made.

In 1916 ammonium sulphate touched the high price of £18. 10s. a ton, and the quantity of it produced in the United Kingdom was 433,000 tons, of which 159,506 tons were got as a by-product of coke-oven works.

In 1917 the total production was 458,617 tons, of which coke-oven works contributed 166,354 tons.

The quality of coke produced from a given coal varies with the degree and with the changes of temperature to which the coal is subjected during the coking process. Different kinds of coal yield different kinds of coke and require different thermal treatment. This matter of the right treatment of coal to give the best yield of coke still awaits a full investigation.

As indicating the value of such research, mention may be made of some interesting results of laboratory experiments by French scientists, Messieurs Georges Charpy and Marcel Godehot. (See *Iron and Coal Trades Review*, September 27, 1918.) They show how much the quality of the coke may be altered by varying the admixtures of different coals, or by the addition to the coal of pitch or tar, or by a preliminary partial distillation of the coal at a low temperature.

A French coal containing 11 per cent of volatile matter could not be made into coke at all by itself.

Mixed with 25 per cent of a Durham coal containing 28·1 per cent of volatile matter, and coked at a temperature of 700° C., it yielded a coke strong enough to resist crushing up to a pressure of 340 lb. per sq. in.

With 51 per cent of the Durham coal, the strength of the coke was increased to 1140 lb. per sq. in. But further additions of the Durham coal rapidly reduced the strength, till, with 56 per cent of it, the strength was nil. By adding pitch to the French coal till the volatile content of the mixture was 28·8 per cent, the strength of the resulting coke reached a maximum of 1850 lb. per sq. in. The addition of tar had a similar effect to that of pitch.

The Durham coal containing 28·1 per cent of volatile matter yielded a puffed and friable coke of no strength.

By heating this coal at a temperature of 450° C., for two hours, the volatile content was reduced to 18·12 per cent. After this preliminary treatment, a coke was obtained from it at 700° C., having a crushing strength of 1310 to 1510 lb. per sq. in. But a further reduction of the volatile content, by continuing the preliminary low temperature distillation, rapidly lowered the strength of the resulting coke, till it became nil when the volatile content was 14·84 per cent. There is a wide field for useful research in the manufacture of coke.

In his Appendix to the Final Report of the Coal Conservation Committee, Professor W. A. Bone gives the following chemical analysis as typical of a first-class Durham coking coal in large blocks freshly hewn from the seam—on the dry coal.

	Per cent.
Carbon	83·75
Hydrogen	4·75
Nitrogen	1·10
Sulphur	1·30
Oxygen	7·50
Ash	1·60
	100·00

"Volatiles" expelled at 900° C., 20·7 per cent.

The following is a chemical analysis of first-rate blast-furnace coke:—

	Per cent.
Fixed carbon	93·64
Volatile hydrocarbons	0·60
Ash	5·36
Moisture	0·40
Sulphur	0·85

The demand for coke arose during the latter half of the eighteenth century, when the supply of charcoal which had been used previously in the making of iron was becoming scarce.

The manufacture of coke began a long time before that of gas.

As the charcoal had been made by burning wood in mounds, so at first the same method was practised in making coke from coal, by burning large piles of coal of 40 to 100 tons with a central chimney to create a draught. This was a very wasteful process, as little more than 30 per cent of the coal was got as coke. Burning the coal in closed chambers built of fire-brick was soon introduced, and a circular form of chamber 10 to 12 feet in diameter with a dome like an old-fashioned beehive was generally adopted. The charge of coal of 6 or 7 tons is dropped into the oven through a hole in its roof and carefully levelled by an attendant working with a rake through the doorway in front of the oven. Air is admitted to the oven, during the process of burning, through small vent holes at the top of the door, and these openings are regulated by the coke burner so as to vary the amount of air at different stages of the process. The escape of the gases into the main flue is also regulated by a damper. When the burning is completed, water at high pressure is directed through hose pipes on to the hot coke in the oven, and thus having been cooled it is pulled out of the oven through the doorway on to the coke bench by men handling long rakes. Coke of excellent quality is thus obtained, in large pieces, and having a silvery lustre attractive in appearance. This silvery lustre is due to a coating of graphite, and adds to the value of the coke by increasing its combustibility in the blast furnace.

The newer type of by-product retort oven was developed on the Continent, and began to be introduced into this country thirty to forty years ago. In 1882 Messrs. Pease & Partners installed twenty-five Simon-Carvés ovens with a recovery plant for tar and sulphate of ammonia. Having proved a success, additional ovens of the same type were soon erected, with extended recovery plant to include benzol.

There are many varieties of the newer retort ovens, but, in all, the oven is heated from the outside, by the hot gases produced in the process, which are drawn through a system of flues constructed vertically in some, and in others horizontally, at each side of the oven.

The oven itself is a long narrow chamber about 30 feet long by 6 or 7 feet high, by 20 inches wide. No air is admitted into the oven. Latterly the tendency has been to increase the size of these ovens, as this admits of economy both in first cost and in cost of working. Ovens holding a charge of 11 and 12 tons of coal are now being built. The largest now at work in England is the Collin, its dimensions being about 37 feet long by 20 inches wide by 10 feet high. A battery of seventy-two Collin ovens at Middlesbrough is said to be turning out 3000 tons of coke per week. (See "Improvements in By-product Coke Oven Practice," by G. P. Lishman—Society of Chemical Industry, July 1916). The United States Steel Corporation has 3112 by-product ovens, with an aggregate capacity of 12,850,000 tons of furnace coke a year, or on the average about 4000 tons an oven. (See Wm. A. Forbes, *Trans. Amer. Inst. Mining Eng.*, 1918.) The modern American by-product oven will carbonize more than 20 tons of coal per day.

In what are known as "regenerative" ovens the air before being admitted to the flues in the sides of the oven is heated to a high temperature by the waste heat from the heating flues, and thus the consumption of gas for heating the oven is much reduced and a larger output of surplus gas is obtained from the coal. The regenerator consists of flues filled with chequer brick-work, built below the ovens, in passing through which the air is heated before admission to the combustion chamber. The growing adoption of the gas engine tends to the choice of this regenerative type of oven, which yields more gas. But at present the most of the gas produced in by-product ovens, probably 80 per cent of it, is used for heating steam boilers. The regenerative oven also yields a higher production of coke than the non-regenerative type, as the process is accelerated by the pre-heating of the air.

Before being charged into the oven, the coal, washed and crushed, is compressed by electrically-driven beaters in a charging-box. The hardness of the coke produced, and its

BY PRODUCT OVENS AND RECOVERY PLANT AT BARGOED COLLIERY, SOUTH WALES

efficiency for the blast furnace, are much improved by these preliminary processes. The coke is driven out of the oven by a ram machine, and is watered as it comes out on the coke bench.

There is always a vertical fissure running longitudinally right through the issuing mass of coke, due to the heating being from each side of the oven. The coke falls from this fissure on each side in small pieces compared with beehive coke, and the exposure to air before quenching gives it a comparatively dark and dirty appearance.

The coke from retort ovens is distinctly inferior in size and appearance to good beehive coke, and the latter still fetches a higher price in some quarters. An advantage of the beehive oven is that it can be much more readily laid idle, when trade is slack, and started again when required.

The much higher first cost of the retort ovens and by-product plant, which cannot be put at less than about £1000 per oven, at pre-war prices, has been a deterrent also to their adoption. But the appalling wastefulness of the Beehive oven in the loss of all the valuable by-products is leading to the general adoption of the by-product oven.

It has been estimated, by Professor Wm. A. Bone, that the realizable profits passing into the air by coking 6½ million tons of coal in Beehive ovens is not less than £2,000,000 per annum!

The retort oven is a much more economical producer of coke, yielding, with Durham coking coal, about 75 per cent of coke from each ton of coal put into the oven, in comparison with about 60 per cent from the Beehive. There is also a great saving of time occupied by the process, the retort oven being burnt off every thirty-six hours (about) in comparison with eighty-four hours of the Beehive.

Coke making is an adjunct of the coal-mining industry of growing importance now that valuable substances like ammonium sulphate, benzol, and tar can be obtained as by-products of the process.

In 1913, 12,798,996 tons of coke were made in coke ovens, and 7,830,736 tons at gas works, a total of 20,629,73 tons of coke, valued at £17,456,461.

The quantity of coal used in making this coke was 37,483,944 tons.

21,006 coke ovens were in use, of which 13,167 were Beehive ovens and 7839 by-product recovery ovens.

The different kinds of ovens in use in 1913 and in 1917 were as follows:—

	In 1913.	In 1917.
Coppee	1926	1415
Simon-Carvés	1402	1756
Otto Hilgenstock	1597	2217
Semet-Solvay	1107	1357
Koppers	814	1361
Huessener	374	439
Simplex	275	486
Bauer	52	—
Collins	45	171
Mackay-Seymour	32	32
Beehive	13,167	7013
Other kinds	215	293
Total	21,006	16,540

Though the total number of ovens in use in 1917 was so much smaller than in 1913, yet the output of coke was rather larger, being 13,555,051 tons. But the coal used was much less, being 28,088,976 tons in comparison with 37,483,944 tons in 1913. This shows the increased production of the by-product oven as compared with the Beehive.

Ammonium sulphate and tar were the chief by-products of coking plant in this country during the year 1913, according to a statement in the Home Office Report.

TAR

Both from a chemical and from a commercial point of view, there is no more interesting or valuable industrial product than coal tar. From it are derived a varied host of useful substances, including dye-stuffs, pigments, perfumes, medicines, disinfectants, explosives, photo developers, and many chemicals.

That coal tar, an unattractive fluid which for long was regarded as good for little but to be burnt, should be made to yield beautiful colours, delicate perfumes, useful medicines, saccharine (the essence of sweetness), and many other valuable substances is one of the most wonderful achievements in the whole range of chemistry. It is a classic example of the value of pure science as the ally of industry, but also unfortunately of our national tendency hitherto to ignore that fact.

The coal-tar colour industry began in England with the discovery by Perkin of the aniline colour "mauve," in 1856.

"Up to 1875 the British industry was in a flourishing condition, and fairly held its own against foreign competition; and a very large number of important patents were taken out in this country."

"The neglect of scientific research during the next decade was the reason why the coal-tar colour trade, established as it was in this country, gradually got forced out by German competition."[1]

But according to Lord Leverhulme, the fault lay with our Government. (See *Times*, May 1, 1919.)

"When the discovery was made of the by-products of coal tar by an Englishman, the conditions of the taxation of alcohol in this country made it impossible for British manufacturers to build up the discovery successfully as a British industry. The Chancellor of the Exchequer would not remove the tax, and the industry passed to Germany."

The remarkable development of this industry, with all its extensive ramifications, which took place in Germany during the thirty years preceding the war is evidence of what can be achieved by scientific research working hand in hand with business enterprise and foresight, and ability and hard work, and backed by capital, when helped and not hindered by the Government.

In the words of Professor W. H. Perkin, F.R.S., referring to our position at the beginning of the war:

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[1] See "The British Coal Tar Industry," by Prof. W. M. Gardner, page 303. Paper by F. M. Perkin, Ph.D., F.I.C. (a son of the discoverer).

"The seriousness of the position is readily grasped when it is borne in mind that the value of the colouring matters consumed in this country is at least £2,000,000 per annum, and that more than 90 per cent of this quantity comes from Germany; and when it is remembered that these dyes are essential to textile industries representing at least £200,000,000 per annum, and employing more than 1,500,000 workers, it is easy to see to what an alarming extent these great industries are in the grip and power of the Germans."

The Right Honourable Lord Justice Moulton made a special investigation of the matter on behalf of the Government, and he points to some of our deficiencies in the following remarks:—

"The fact was that chemistry opened up, especially some fifty years ago, a domain of industrial wealth which he could only compare to the domain which was opened up when steam power was first invented; and to his great sorrow he could come to no conclusion but one, and that was, that either from being too well off, or from sluggishness of intellect, or from the fact that the capital of the country had passed into the hands of people who were unwilling either to learn or to think, England had abstained almost entirely from attempting to reap the rich harvest that was opened to the industrial world by the advances in organic chemistry."

Again Lord Moulton has pointed out the weak spot as follows:—

"The Englishman is excellent at making the best of the means at his disposal, but he is almost hopeless in one thing. He will not prepare himself by intellectual work for the task that he has to do. Now there is the cause and, so far as is material, the sole cause of the German supremacy. Is that a cause which must permanently operate? The answer is of course, 'No.' But it is for us to reform ourselves; otherwise no relief can come."

Similarly our sins in the past have been well expressed by Mr. William Pickup in his address as President to the

Manchester Geological and Mining Society, November 1917 (*Trans. Inst. Mining Eng.*, vol. lix.).

"We have been occupied in the past by our prosperity; we have been obsessed by admiration of our own achievements, too confident of the sufficiency of our limited knowledge; too contemptuous of the few who tried to throw the light of science on our path; too eager for wealth; and too careless of the needs and aspirations of our work people."

"Happy are they that hear their detractions and put them to mending."

Evidently there has been a good deal of apathy and indolence in our industrial methods in the past, and fortunately this is now being generally recognized

One factor in the successful development of the coal-tar colour and organic chemical industry in Germany has been their early and general adoption of the by-product coke oven.

In these ovens about 20 gallons of tar are got on an average from each ton of coal carbonized.

The rapid adoption of the by-product oven which is now taking place in this country is drawing increased attention to the potentialities of coal tar.

That it is worthy of consideration may be gathered from the following figures of the value of coal-tar products (not dyes) exported during the years 1915 and 1918:—

	1915.	1918.
	£	£
Aniline oil and toluidine	108,752	212,872
Anthracene	1,808	40
Benzol and toluol	430,853	727,684
Carbolic acid	250,992	397,430
Coal tar, crude	3,998	93
,, refined and varnish	55,599	29,555
Naphtha	24,454	22,386
Naphthalene	47,780	304,076
Pitch	341,328	885,452
Tar oil, creosote, etc.,	659,148	80,665
Other sorts	302,387	236,241
	£2,227,099	£2,896,494

These nine or ten direct products of coal tar are transformed by chemical treatment into "250 to 300 different intermediate products which in their turn yield some 1200 chemically distinct dye-stuffs." (See Professor W. M. Gardner, "British Coal Tar Industry," p. 573.)

Coal-tar distillation plants are increasing in number. In 1906 the number registered separately under the Alkali Act was 174; in 1913, 234; and at May 30, 1916, 342. (See "Influence of the War on the Tar-distillation Industry," by W. H. Coleman, Society of Chemical Industry, July 1916.)

It has been stated (1916) by Professor Thomas Gray (now superintendent of the laboratories at the Fuel Research Station) that the total annual output of crude tar in the United Kingdom is approximately 1½ million tons, and he estimates that about 2,000,000 gallons of 90 per cent benzol[1] and 500,000 gallons of 90 per cent toluol might be obtained from it.

As already stated, the composition of coal tar varies greatly according to the nature of the coal from which it is derived, and the method of its production. For instance, tar made from the same coal in a vertical gas retort will be quite different from that made in a horizontal retort, as the following analyses show. A typical analysis of coke oven tar—though not from the same coal—is placed side by side for purposes of comparison. (See paper by Edgar Stansfield and F. E. Carter on "Products and By-products of Coal," *Colliery Guardian*, December 3, 1915.)

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[1] The term "90 per cent benzol" implies that 90 per cent of it will distil over at a temperature of 100° C. or lower.

[TABLE

Coke Oven Tar.	Analyses.	Gas Works Tar.	
		Vertical Retort.	Horizontal Retort.
Per cent.		Per cent.	Per cent.
1·14 to 1·19	Specific gravity about	1·1	1·2
	Free carbon	2·4	20·0
	Distillation yields—		
2·7	Water	2·2	3·5
1·4	Light oil	5·9	3·1
3·5	Middle oil	12·3	7·7
9·9	Heavy oil	12·0	10·2
24·8	Anthracene oil	16·0	11·6
56·4	Pitch	49·7	62·0

These oils are distilled over at different temperatures, about as follows:—Light oil (specific gravity, 0·90 to 0·95), up to 170° Centigrade; middle oil (specific gravity, 1·01), 170° to 230° Centigrade; heavy oil (specific gravity, 1·04), 230° to 270° Centigrade; anthracene oil (specific gravity, 1·10), 270° to 400° Centigrade.

Coke oven tar usually contains less free carbon and is more fluid than gas works tar.

In practice, coke ovens yield 4 to 5 per cent of tar per ton of coal; low-temperature processes from 10 to over 20 per cent, varying with the quality of the coal; and gas-making plants with horizontal retorts yield an average of 9 to 13 gallons of tar per ton of coal. (See paper on "Fuel Oils from Coal," by Harold Moore, read February 26, 1916, before Manchester Association of Engineers.)

The low-temperature carbonization of coal in chamber ovens yields liquid products suitable for use in Diesel engines. A large number of these engines are now running on tar oil. This development is of special value in face of the scarcity of petroleum. Large supplies of fuel oil are required for the Navy.

Below are given figures of actual results obtained in Co. Durham from by-product coke ovens, and the money value of the products per ton of coal at prices prevailing in the autumn of 1915.

PRODUCTS OBTAINED FROM 1 TON OF CLEAN DRY BITUMINOUS COAL IN RETORT COKE OVENS.[1]

	Per cent of Money Value.	Per cent of a Ton.		Value of Products per Ton of Coal put into Oven.	
				s.	d.
Coke .	72·6	0·75		15	5
Benzols .	6·7	0·01	yielding 90 per cent benzol . 0·004 Toluols . . 0·015 Solvent naphtha . 0·004	1	5
Tar .	5·4	0·045	yielding heavy oils . . 0·009 Pitch . . . 0·024	1	2
Ammonium sulphate .	13·0	0·01		2	9
				20	9
Steampower	2·3	112	Board of Trade units (Kilowatt hours) .	0	6
	100 0			21	3

According to these figures 100 tons of this coal will yield 75 tons of good foundry coke, 4½ tons of tar, 1 ton

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[1] Professor Bone (Appendix to Final Report—Coal Conservation Committee, 1918) gives the following figures (as estimated by Mr. Bray on the basis of prices prevailing before the war, 1910–1912) of the money value of products per 100 tons of coal coked.

	Gross Value.	Cost of Recovery.	Net Value.
	£ s. d.	£ s. d.	£ s. d.
1 ton ammonium sulphate .	12 0 0	2 10 0	9 10 0
4·5 tons tar at 18s. . .	4 1 0	0 9 0	3 12 0
300 gals. crude benzol at 5d. .	6 5 0	1 17 6	4 7 6
Total per 100 tons of coal .	£22 6 0	£4 16 6	£17 9 6

This shows a profit of 3s. 6d. a ton of coal put into the oven without taking into account the value of the surplus gas.

of ammonium sulphate, and 1 ton (about 250 gallons) of crude benzol, and 112 Board of Trade units of electrical power. This applies to good bituminous coal which has been washed and crushed, and dried and compressed in a charging machine.

The crude benzol in this instance is washed out from the gaseous product of the ovens by treatment in rotary scrubbers with creosote oil got from the distillation of the tar, and from the crude benzol thus obtained are got by distillation the 90 per cent benzol and toluols and solvent naphtha ("solvent" because it is used to dissolve rubber and other substances, and as a solvent in the purification of anthracene). In this case no benzol is got from the tar.

The products obtained by distillation of the tar are pitch (the solid residue), and heavy oils, chiefly creosote, napthalene, and anthracene. It must be acknowledged that under present circumstances there is not much profit to be made out of the tar in these small plants connected with isolated coke yards. To make it profitable, the industry must be conducted on a large scale, and organization and co-operation are necessary.

The difficulty is to find a profitable outlet for the pitch and the creosote oil, which constitute much the largest portion of the product of coal-tar distillation. Only about 10 per cent of the tar can be utilized for making dyes and chemicals. What is needed is some means of utilizing the enormous quantities of coal tar and pitch which are accumulating throughout the country.

Next to the coke the most profitable by-product at present is the ammonium sulphate.

In the Durham instance the waste gases after the extraction of these products are utilized to raise steam in Galloway tubular boilers. The steam drives electric generators, and the power thus obtained as measured by electric meters amounts to 112 kilowatt hours per ton of coal carbonized.

At present the coke is much the most valuable product, but the day may come when the surplus gas and tar and ammonium sulphate and benzol are of more value than the coke.

As regards the relative value of the by-products, it has been stated by Mr. D. Bagley that, taking what may be termed the average values for ammonium sulphate, benzol, and tar in 1916, their respective contributions to the gross revenue of a coke works expressed in percentages were in the variable ratios of 47 per cent, 32 per cent, and 21 per cent respectively, fluctuating with the nature of the coal, distilled values, etc.

In the Durham example this ratio is ammonium sulphate, 52 per cent; benzol, 26 per cent; and tar, 22 per cent.

Considering the demand for motor fuel, and the possible extension of the aniline industry, it is not improbable that benzol may take the foremost place in the future.

According to a statement published by the U.S.A. Geological Survey about the working of 5142 by-product ovens which were in operation in the U.S.A. during the year 1914, the average value of the by-products was 5s. 3·28d. per ton (2240 lb.) of coal used and 7s. 3·36d. per ton of coke produced. This was equivalent to 46 per cent of the value of the coke produced, as compared with 35 per cent in 1913, and 34 per cent in 1912.

These results are much the same as those obtained in the Durham example given above, where the value of the by-products is 5s. 10d. per ton of coal used, and this constitutes 38 per cent of the value of the coke produced.

As further evidence of the products which may be got from bituminous coal, the following figures given by Professor John S. S. Braine in his Howard Lecture before the Royal Society of Arts (January 1917) may be quoted:—

AVERAGE YIELD OF 100 TONS OF BITUMINOUS COAL.

Coke . . .	65 tons
Sulphate of ammonia .	1¼ ,,
Cyanide of sodium .	2 cwt.
Gas tar . . .	975 gallons --(5 tons)
Coal gas . . .	1,100,000 to 1,200,000 cub. ft.

The products vary, of course, according to the quality of the coal carbonized. There is considerable difference, for instance, between the yields got from Durham coal, and from Yorkshire or Welsh coal.

From information received from two of the largest builders of by-product coke ovens in the kingdom, Professor Bone has summarized the results approximately as follows:

"Each ton of dry coal carbonized yields, according to the locality, from 55 to 85 lb. of anhydrous tar, from 1·75 to 3·5 gallons of crude benzol (two-thirds of which may be ultimately obtained as refined products—benzene, toluene, solvent and heavy naphthas), and from 20 to 30 lb. of ammonium sulphate."

CHAPTER XIV

COAL MINING AND THE LEGISLATURE

THE industry of coal mining and the colliery manager stand in a unique position in their relation to the legislature.

In the words of the late Mr. R. M. Johns, of the Middle Temple: "In no other industry save mining has it been attempted by Act of Parliament to lay down precise rules and regulations for the conduct of the actual operations of a commercial undertaking." More recently the legislature has gone so far as to place a limit by Acts of Parliament to the hours to be worked by those engaged in the industry, and to the minimum wages to be paid to them.

As regards the colliery manager, the legislature has thrown upon him, to quote another lawyer, "under various circumstances, a primary responsibility (which he can only rebut upon proof) should any person whomsoever contravene, or fail to comply with, its numerous stringent provisions."

During the first half of last century, when coal mining was expanding rapidly with the advent of the steam engine, the development of railways and canals, and the growth of the iron trade, public attention was increasingly called to it by the serious explosions causing much loss of life which occurred too frequently in coal mines.

The first efforts to prevent these disasters were due to the personal initiative of public-spirited individuals, who voluntarily formed committees to investigate the matter and to seek a remedy. The Northern coal-field (Northumberland and Durham) was the most important, and the first efforts were made in that district. The Sunderland Association formed in 1813 led to the invention of the first miners' safety lamps by (see "Notes on the History of the Safety Lamp," by Prof. F. W. Hardwick and Prof. L. T. O'Shea, *Trans. Inst. Mining Engineers*, 1916, vol. li.) Sir Humphry Davy, and independently by George Stephenson and by Dr. Clanny, and the South Shields Committee of 1839 to 1842 brought about the passing of an Act of Parliament in 1842, which may be taken as the beginning of mining legislation in the modern sense.

The prohibitions contained in this Act indicate something of the progress that has been made in social conditions during the last seventy years. It prohibits the employment underground of women and girls, and of boys below ten years of age, and the payment of wages at or near public houses!

Since 1842 there have been more than a dozen Acts of Parliament regulating the working of collieries, culminating in the Coal Mines Act, 1911. Most of this legislation has been based upon the elaborate reports of Royal (or other) Commissions which have collected and sifted a large amount of personal evidence and of varied information bearing on the subject. Three guiding ideas are apparent throughout: (1) The establishment of rules and regulations likely to prevent accidents; (2) the daily control of every colliery by a competent manager who is personally responsible for the observance of these rules and regulations and liable under penalties for the breach of them; (3) the appointment of inspectors to see that the provisions of the Acts are complied with.

It is the manager who has to bear the burden. He has to translate into practice the legal phraseology of the Acts, by no means an easy thing to do, as the meaning is frequently far from clear. He has the responsibility of finding and appointing the officials, upon whose competence so much depends. "The manager shall appoint in writing to be officials of the mine such number of competent persons as will be sufficient to secure a thorough supervision of all operations in or about the mine. He shall assign their duties to the several officials of the mine" (Coal Mines Act, 1911, Regulations and Orders). In the event of any breach of rules *by any person whomsoever*, he is assumed to be guilty of an offence against the Act unless he proves that he had taken all reasonable means to prevent it. "The substantial responsibility of compliance with the law, which means (in the event of failure or omission) liability to heavy penalties, rests in practice on the colliery manager."

It was the Act of 1872 which first instituted Examination Boards for testing the competency of would-be managers, and laid it down that a colliery must be under the daily supervision and control of a manager holding a certificate of competency granted by the Secretary of State.

This system was developed by the Act of 1887, which established a new class of under-managers, holding second class certificates of competency; and the Act of 1911 extends the principle to Surveyors, and to Firemen, Examiners, and Deputies, who now must be the holders of certificates.

It is an open question whether this test by examination as now enforced for Firemen, Examiners, and Deputies does not exclude some of the best men, who, by practical underground experience and natural aptitude, are specially fitted for the post. A scarcity of suitable men has been experienced since the passing of the Act.

HOME OFFICE CONTROL

For the purpose of administrative control by Inspectors of Mines under the Home Office, the United Kingdom is divided into six districts. The Order of the Secretary of State effecting this division is dated April 23, 1913:—

(1) Scotland Division.
(2) Northern Division.
(3) York and North Midland Division.

(4) Lancashire, North Wales, and Ireland Division—in 1913 subdivided into—
  (*a*) Manchester and Ireland District.
  (*b*) Liverpool and North Wales.[1]
(5) South Wales Division.
(6) Midland and Southern Division.

The output of coal and the number of mines under the Coal Mines Acts at work in each of these districts during the year 1913 was as follows:—

	Tons.	Number of Mines.
Scotland	42,456,516	542
Northern	58,675,687	507
York and North Midland	72,951,841	635
[1] North and East Lancashire	11,289,206	214
Ireland	82,521	22
Liverpool and North Wales	16,841,549	218
South Wales	56,830,072	609
Midland and Southern	28,284,387	542
	287,411,869	3289

[1] Now amalgamated into one district.

This does not include 18,604 tons got from open quarries.

The outputs of the various districts bear roughly an inverse proportion to their area, the three smallest districts in area, namely, Northern, York and North Midland, and South Wales, having the largest outputs; and together accounting for about 65 per cent of the total output, and of the total number of persons employed.

The diagram shows the production of the districts in percentages in 1915 (p. 146).

In 1913 there were 91 inspectors, namely, the Chief Inspector, the Deputy Chief Inspector, the Electrical Inspector of Mines, and 88 others, classed as follows:

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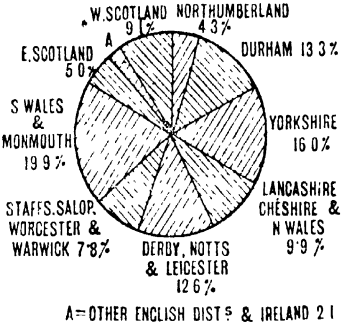
[1] These two subdivisions were amalgamated subsequently into one, "Lancashire, North Wales, and Ireland Division."

7 Inspectors in Charge, 12 Senior Inspectors, 33 Junior Inspectors, 30 Sub-Inspectors, and 6 Inspectors of Horses.



Production of Districts, 1915.

They were allotted to the different districts as follows:—

	Inspectors in Charge.	Seniors.	Juniors.	Sub-Inspectors. Mines.	Sub-Inspectors. Quarries.	Inspectors of Horses.
Scotland	1	2	5	4	1	1
Northern	1	1	7	4	1	1
York and North Midland . .	1	2	6	4	1	1
Manchester and Ireland . .	1	..	3	1	1	1
Liverpool and North Wales . .	1	2	2	2	1	
South Wales.	1	3	5	4	1	1
Midland and Southern . . .	1	2	5	3	2	1
	7	12	33	22	8	6

These are the figures for 1913–14. Subsequently some small changes were made, and in 1916–17 there were 6 Inspectors in Charge, or Divisional Inspectors, 14 Senior Inspectors, 32 Junior Inspectors, and 8 Inspectors of Horses, making a total of 93, as compared with 88 in 1913.

A Labour adviser to the Home Office had also been appointed.

In the Civil Service estimates for 1916–17, the cost of inspection of mines and quarries is as follows:—

Previous Year.		1916–17.
£35,169	Salaries and allowances	£36,260
18,650	Travelling and incidental expenses . .	17,190
3,325	Cost of inquiries, arbitration, etc. . . .	3,200

The salaries are not excessive. In this connection it is interesting to note that the cost of the Coal Controller's Department during the financial year 1918–19 was approximately £250,000, and the estimated cost for the year 1919–20 is £517,253!

As showing the trend of legislation, it is interesting to remember that it was by an Act passed in 1850 that authority was first given to a Secretary of State to appoint and remove inspectors of mines with powers of entry, both underground and on the surface, and of inquiry into all matters concerning the safety of the men employed.

The number of them appointed at first was two, but after the passing of another Act in 1855 their number was increased by six, and the country was divided into twelve inspection districts.

After the Act of 1872, a new class of junior or sub-inspectors was appointed, one of them being attached to each head-inspector.

The present number of inspectors shows the expansion that has taken place recently.

This development of bureaucratic control is apparent also in the multiplication of Rules.

By the Act of 1855 seven General Rules, dealing with such matters as ventilation, signalling arrangements, shafts, and cage guides, were made legally binding on all collieries. Besides these General Rules, it was enacted that Special Rules directed to the prevention of accidents should be made for each colliery, subject to the approval of a Secretary of State.

By an Act of 1860 the number of General Rules was increased to fifteen, and their scope was considerably enlarged, and in the Act of 1872 they were further developed, and increased in number to thirty-one. Again, in the Coal Mines Regulation Act, 1887, eight more rules were added, making thirty-nine.

As regards the Special Rules, the original intention was that each colliery should have its own code applicable to its own particular conditions, but what happened was that in each mining district one code was settled for all the collieries in the district.

In 1908 there were twenty-four codes of Special Rules, varying in the number of the rules in each code from ninety-three rules in South Staffordshire to 247 rules in South Wales.

The Act of 1911 has introduced a new principle, in that it gives power to the Secretary of State not only to vary and amend any of the "Provisions as to Safety" which are contained in forty-six Sections of the Act, with numerous sub-sections (Part II. Sections 29 to 75), but also gives him power to make by order "such general regulations for the conduct and guidance of the persons acting in the management of mines or employed in or about mines as may appear best calculated to prevent dangerous accidents and to provide for the safety, health, convenience, and proper discipline of the persons employed in or about mines, and for the care and treatment of horses and other animals used therein."

These Regulations before coming into force are to be published for the information of persons affected, who may make objections in writing, which will be considered by the Secretary of State, and may be referred for decision to one of the panels of referees appointed under the Act.

Under these powers a very large number of General Regulations and Orders have been issued.

The General Regulations which came into force on July 15, 1913, number 190, and these, it should be remembered, are in addition to the "Provisions as to Safety" contained in the main Act.

Besides these, nine General Regulations have been issued as to the hours of employment of Winding Enginemen.

An Order relating to the use of Explosives in Coal Mines, containing a large number of stringent provisions, divided into General Provisions, Special Provisions, and Supplemental, and a list of twenty-five Permitted Explosives named and defined, came into force on September 15, 1913.

SAFETY LAMP ORDERS

A new provision of the Act of 1911 is that no safety lamp may be used unless "it is of a type for the time being approved by the Secretary of State."

In pursuance of this provision "The Safety Lamps Order of August 26, 1913," appeared. It names and describes thirty-one safety lamps, grouped into—

14 Flame safety lamps approved for general use.
11 Flame safety lamps approved for use by officials only.
4 Electric safety lamps approved for general use.
2 Electric safety lamps approved for use by officials or for special purposes only.

It also defines eleven brands of Safety Lamp Glasses which only may be used.

Other Orders which have been issued under the Coal Mines Act, 1911, relate to—

(1) The use underground of apparatus for the relighting electrically of safety lamps.
(2) Manner of search of persons employed below ground for prohibited articles before the commencement of work.
(3) Manner of settling disputes under the Act.
(4) Procedure for ascertaining and certifying views of workmen.

The rules regarding Electricity alone are said by one who has had the temerity to count them to number 2000!

This mass of Orders and Regulations, though it speaks well for the industry and activity of the Home Office, is somewhat overpowering for those engaged in the practical management of collieries. The colliery manager runs some risk of being submerged under a torrent of legislation.

A manager, wishing to keep himself outside the clutches of the law, has to be constantly thinking about the rules, instead of about the safety of the workmen.

It is commonly reported that at a Government inquiry into an accident an honest but too impulsive inspector blurted out to the manager who was under examination: "It is the rules you have to consider, not what you think is conducive to the safety of the men"!

The rapid succession of new Orders amending and adding to those made a few months previously is evidence of undue haste and of a want of proper consideration for those who are affected by them.

Accompanying this new activity of legislation, there has been an increasing rigour in the prosecution of managers for anything which can be construed to be an offence under the Act. Since the Act came into force, there has been much litigation, and the nature of some of the prosecutions gives some ground for the view that the guiding motive is punitive rather than preventive.

"Our legislature grows authoritative, grows philanthropical, bristles with new duties and with new penalties, and casts a spawn of inspectors, who now begin, with note-book in hand, to darken the face of England" (R. L. Stevenson in "The Day after To-morrow").

A special feature of the Act of 1911 is the multiplication of reports. Section 17: "In addition to the reports specially required by this Act, it shall be the duty of every person on whom responsible duties are imposed with respect to safety or to the condition of the roadways, workings, ventilation, machinery, shafts, shot-firing, safety lamps, electrical plant, or animals at a mine . . . to make . . .

in a book to be kept at the mine, full and accurate reports of the matters falling within the scope of his duties."

Many of the persons employed in mines, while they are quite competent and capable of performing the responsible duties imposed on them, and of expressing themselves by word of mouth, are no good at writing full and accurate reports in a book. These reports are apt to become stereotyped, and of little value.

Under this Act, a manager of mines employing on an average 1600 men and boys and producing about 1700 tons of coal daily—not a big place—has to examine and sign 104 reports daily, and forty-four weekly besides. He has also to make ten Yearly Returns for each colliery.

Many think that his time might be better employed.

One of the greatest evils of Government Control, as it has been experienced during the war, is the toll it takes on the time and energy of managers in making Returns to State Departments—time which normally would be exercised in promoting the efficiency of industry.

It must be admitted that the Coal Mines Act, 1911, goes far—much too far, as many think—towards making colliery management—without its responsibility—a function of the Home Office. In their effect on Colliery Management, the General Regulations and Orders are more drastic than the Act itself, and these Orders and Regulations emanate from the Home Office, not from Parliament.

It is impossible to draw up any lengthy code of Rules and Regulations which shall be equally applicable to and effective for all collieries. Coal mines are not like factories which are entirely the work of men's hands, and may be made after one uniform pattern to suit general regulations. The natural conditions of coal mines, such as depth, thickness, and gradient of seams, hardness of roof and floor, gas, water, and coal dust, vary enormously at different collieries, and cannot be altered.

It follows that a rule which is most suitable and useful for some collieries lays an altogether unnecessary burden on others. The circumstances of the case demand that a wide latitude should be allowed to those who have the responsible management of collieries, but the aim of recent legislation seems to be, to leave as little as possible to the discretion of the individual manager.

RESCUE APPARATUS

Unnecessary and useless regulations do not encourage respect for the law or ready obedience to it. Certainly some of the new regulations have been premature and ill-considered. An instance is the obligation to provide rescue breathing apparatus. Part IV. Section 142: "There shall be provided and maintained at every mine suits of portable breathing apparatus . . . capable of enabling the wearer to remain for at least one hour in an irrespirable atmosphere."

Eight years after this edict was launched, "owing to the unsatisfactory and sometimes fatal results obtained with some of the types of self-contained breathing apparatus in use," a Research Committee was appointed by Government to investigate the subject!

In the meantime several men have lost their lives in using breathing apparatus, and in their First Report, issued in September 1918, the Research Committee pointed out many dangers attending the use of existing apparatus.

To compel the use of dangerous apparatus is hardly a right function of Government.

SIGNALLING

There are other instances of requiring the provision of new appliances which are difficult to obtain in satisfactory form—as, for instance, Signal Indicators.

"In connection with every winding engine there shall be provided an appliance which shall automatically indicate in a visible manner to the winding engineman (in addition to the ordinary signal) the nature of the signal until the signal is complied with."

When no thoroughly approved appliance of the kind exists, there is a probability of apparatus being provided with the best intentions which yet may not entirely fulfil the meaning of the regulation as interpreted by a Government Inspector. It may be said, perhaps, that such regulations stimulate invention, and that the demand creates the supply, but it is hardly fair to saddle an industry with the statutory obligation to provide appliances before they exist, or before they have been tested by experience.

EXPLOSIVES ORDERS

The new regulations governing the use of explosives have been severely criticized, and not without reason

Blown-out shots are undoubtedly one of the chief dangers in gassy or dusty mines, and many explosions have been due to them.

To remove this danger is the very laudable desire of Government officials and of all who are engaged in mining.

In 1897 a Government station was established at Woolwich for testing explosives in order to enable the Home Secretary to exercise his powers of prohibiting the use in mines of such as are dangerous. It is the temperature attained by the detonation of the explosive, and the length of time during which this high temperature lasts, that determines its degree of danger. Any explosive, if a sufficient quantity of it is fired in an unstemmed shot into an explosive mixture of gas and air, will ignite the mixture. Hence has arisen the practice of determining the safety of explosives according to the weight of them which can be fired without igniting gas or coal dust.

This practice of the *charge limité* has been generally adopted in continental countries for some years past, and now under the new regulations in England also.

It was first proposed in 1903 at the International Congress of Applied Chemistry at Berlin by M. Victor Watteyne, who was in charge of the Belgian testing station at Frameries.

The apparatus at our old testing station at Woolwich did not permit of experiments being carried out to determine the "limiting charge," the gallery being too small. A new station therefore was instituted at Rotherham in the centre of the Yorkshire coal-field

Here the gallery is 5 feet in diameter (twice the diameter of the old one at Woolwich) and 50 feet long—made of iron. The cannon in which the shots are fired has a bore 2 inches diameter and 4 feet long.

The *modus operandi* is described officially as follows:—

"Shots will be fired into a mixture of gas and air until the largest charge which can be fired without igniting the mixture is found. Further shots will then be fired, beginning with this charge, and in the event of an ignition reducing the charge, until five shots of the same weight have been fired without igniting the mixture.

"Shots will then be fired with the charge so determined into coal dust, and the same procedure adopted, until five shots of the same weight have been fired without igniting the coal dust.

"The lower of the charges thus determined will be known as the 'maximum charge.'"

But experience has proved that the determination of this maximum charge is not so simple as perhaps at first sight it may appear to be. The same explosive has been saddled with a widely varying maximum charge as determined at different testing stations, of which there are several abroad.

It has been found that this "maximum charge" is altered by many conditions, such as the area of the gallery, the diameter and the length of the bore, the nature of the gas, whether coal (lighting) gas or pit gas, the quantity of coal dust present in the dust mixture, and variations in the atmospheric pressure.

And these conditions do not affect all explosives alike, but react differently on different explosives according to their composition and their products of combustion.

All this is clearly set out and explained by the late

Professor Vivian B. Lewes in a paper read before the Royal Society of Arts on April 2, 1913.

A reduction in the size of the gallery checks the expansion of the products of combustion, and this does not affect all explosives alike.

At Rotherham the cartridge occupies about half the sectional area of the hole. The air space thus left has the effect of cooling the products of combustion, and with explosives giving off carbon monoxide it has been shown that this much increases the maximum charge above what it is when the cartridge fits the hole. The length of bore of the cannon has a similar cooling effect.

Again a rise of atmospheric pressure increases the weight of oxygen present in each cubic foot of air, and this makes a coal dust mixture more liable to ignite, and reduces the "maximum charge."

Meteorological conditions have an effect upon the speed of detonation and the rate of propagation of the flame.

It was not without reason. therefore, that Professor Lewes stated that "The only true test of the safety of mining explosives is the practical one of use in coal mines over many years, and when an explosive has been in use on a large scale for over twenty years, tons of the material having been used and millions of shots fired under every condition conceivable in practice, without a single accident being traceable to its legitimate use, such an explosive holds a certificate of safety that no series of tests under empirical and artificial conditions could ever give it."

Some 26,000,000 lb. of explosives are used yearly, and about 48,000,000 shots are fired at mines in the United Kingdom under the Coal Mines Regulation Act. In 1913 the figures in the Official Report are 48,834,286 estimated number of shots fired, and 26,335,195 lb. of explosives used, of which 10,624,893 lb. or about 40 per cent, were permitted explosives.

The quantity used varies very much in the different mining districts, from 6·1 tons of coal per pound of explosives in Scotland to 40·8 tons in the Yorkshire and North Midland Division.

Rather less than half the total number of shots were fired by electricity.

The resulting fatalities caused by their igniting gas during the year 1911 numbered only four, and during 1912 three, and during 1913 there was only one fatal accident due to explosion of firedamp or coal dust by shot firing in coal mines. This does not suggest the necessity of further burdensome restrictions. But under regulations gazetted September 9, 1913, nearly all the formerly permitted explosives were forbidden.

Of those now permitted the "maximum charge" varies between 8 oz. and 40 oz.

The heaviest charge which may be fired from the gun at Rotherham is 40 oz. = 2½ lb.

Heavier charges than this, of the hitherto permitted explosives, have been commonly used at many collieries working thin seams where considerable thicknesses of hard stone have to be removed to make height.

The last Explosives Order, dated June 19, 1919, is appended—

EXPLOSIVES IN COAL MINES

The Explosives in Coal Mines Order of June 19, 1919, amends the Order of September 1, 1913, by an alteration of Thames Powder No. 2. So much of the Schedule to the Explosives in Coal Mines Order of January 28, 1915, as relates to this explosive is repealed. The composition of the new explosive is as follows:—

Thames Powder No. 2.

	Parts by weight.	
Ingredients.	Not more than	Not less than
Nitro-glycerine	11	9
Nitrate of ammonium [1]	60	57
Chloride of sodium	22	20
Wood-meal (dried at 100° C.)	10	8
Moisture	2	—

[1] Including not more than 2 per cent of carbonate of magnesium.

The explosive is to be used only when contained in a stout case of paper thoroughly waterproofed with a mixture of ceresine and resin; with a detonator or electric detonator of not less strength than that known as No. 6; the greatest weight of the explosive which may be used in any one shot-hole shall not exceed 22 oz. The explosive must have been made at the works of the British Explosives Syndicate Limited, at Pitsea, Essex; or at the works of Nobel's Explosives Company Limited, at Ardeer, Ayrshire. Four ounces of Thames Powder No. 2 gave a swing of 2·59 in. to the ballistic pendulum, compared with a swing of 3·27 in. given by 4 oz. of gelignite containing 60 per cent of nitro-glycerine.

Eight Hours Act and Minimum Wage Act

In the Eight Hours Act (Coal Mines Regulation Act, 1908) and the Minimum Wage Act, 1912, limiting hours of work and wages, we have seen a reversion to the labour legislation of the Tudor period.

The Eight Hours Act,[1] as its name implies, limits the period of work of the underground workman to eight hours in the twenty-four, whether he likes it or not. Previously a good many miners used to increase their earnings occasionally by working overtime, so that indirectly the Act has had the effect of reducing wages. Necessarily also its tendency has been to lower the output of coal per person employed and to increase the cost of production.

In a lecture on "Coal Trade Problems" delivered before the London School of Economics on October 19, 1917, Mr. Arthur Pease gave the following figures as showing the effect of the Eight Hours Act in Co. Durham in reducing the output of coal: "In 1909, the year before the Act came into force, 145,800 men produced 40,361,000 tons of coal, but during 1911, the first complete year of working after the Act, 157,280 persons produced 40,800,000 tons. The number of men and boys employed had increased by 8 per cent, but the output only increased by 1 per cent."

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[1] The eight hours is reckoned from the time when the last man of the shift leaves the surface to the time when the first man is drawn to the surface at the end of a shift. It takes time to lower down the shaft in the cage a large number of men and to bring them up again. At a large colliery it may occupy three quarters of an hour for each operation, or one and a half hours in all. In this event the length of a man's shift from bank to bank may be anything from eight hours to nine and a half hours, but during any excess time over eight hours he is not working, but sitting either at bank or at the bottom of the shaft waiting his turn for the cage. Since the above was written, a Seven Hours Bill, to take effect from July 16, 1919, has been passed, and no doubt will further aggravate the scarcity of coal from which the country is suffering!

There is some ground too for the opinion which is held by not a few that the number of accidents has been increased by the greater rush and hurry which this Act promotes.

The coming into force of this Act was followed by worse disputes and more serious disturbances than had been known for a long time previously.

These troubles were prominent in South Wales, and in the Northern coal-field, districts in which the existing arrangement of labour made the adoption of the Act particularly difficult and upsetting. The years 1910 and 1911 were distinguished by constant sectional strikes accompanied in some cases by serious rioting, which culminated in the national coal miners' strike in the spring of 1912.

This lasted for six weeks, and was patched up by the passing of the Minimum Wage Act.

Under this Act, in every mining district there have been established Joint District Boards—twenty-two of them in all—consisting of representatives of the miners and of their employers, with an independent chairman chosen by themselves, or, in event of their disagreement, appointed by the Board of Trade.

Each District Board has the power of settling general minimum rates of wages and general district rules, which are applicable to all underground workmen in the collieries of its district.

In practice the decision has rested almost always with the independent chairman appointed by the Board of Trade.

Unfortunately this Act encourages the indolence which is so prominent a characteristic of human nature. Instead of exerting themselves to the full to get more coal and a higher wage, a large number of miners are now inclined to take it easy, depending on getting the minimum wage.

The following remark made by an experienced colliery manager during a discussion at a meeting of one of the Mining Institutes is suggestive: "A pick-sharper recently said he could generally tell who were the 'minimum' men, as their picks so rarely came to bank."

There is a remarkable consensus of authoritative opinion about the mischievous effects of this Act.

The President of the Institution of Mining Engineers, Mr. George Blake Walker, has condemned it as "the most pernicious piece of industrial legislation ever inflicted on the country."

Sir Hugh Bell in his evidence before the Coal Commission stated that of all the disastrous results of Government interference with the coal trade, none had been so disastrous as the imposition of a statutory minimum wage.

Mr. Arthur Pease, chairman of Messrs Pease & Partners Ltd., at their General Shareholders' Meeting in June 1919, said: "In my opinion nothing has contributed so greatly to the loss of output and inefficiency of production as the Minimum Wage Act."

Mr. Vernon Hartshorn, M.P., a miners' representative, writing in the *South Wales Daily News* on the serious results of lessening production, states: "A large number of men were placed on the minimum, which removed incentive to raise or maintain output. . . . So large a proportion of the miners are on the minimum or allowance that the output has lost its importance for them."

As the minimum wage is increased in accordance with higher wages, the number of miners who are content with it grows, and the output is decreased in proportion. At Pease's West Collieries, Co. Durham, "the number of men on the minimum wage was only 10 per cent in 1914, whereas for the year ending April 30, 1919, the percentage was 51."

Undoubtedly the Minimum Wage Act is the chief cause of the reduced production per person employed, which is such a disastrous feature of the present industrial position.

Our coal-mining industry has suffered from too much attention being paid to politicians and labour representatives, and too little to the men who have the responsible daily control of coal mines, and whose first interest, even from the most selfish of motives, is the prevention of accidents.

The colliery managers are in touch with the employers on the one hand, and with the miners on the other, and there is no body of men which has a closer acquaintance with all the conditions of the industry. Many mistakes might have been saved, if practical colliery managers had been taken into consultation.

It is a remarkable fact that on the Coal Commission which was appointed to decide matters vitally affecting collieries and the coal-mining industry, there was not a single representative of colliery managers or colliery officials. Yet the managers are the guiding brains of the industry, and on them must always depend to a very large extent its successful control and development.

The only reasonable justification for legislation which lays heavy burdens on an important industry is that it preserves or strengthens human life. Enough perhaps has been said to show that in much recent legislation affecting coal mining, this justification is not apparent.

Accidents are prevented by the knowledge, and the care, and the attention of those engaged in the industry, and this may be assisted by judicious legislation, in raising the general standard, and bringing up defaulters. Legislation alone can never prevent accidents.

The large increase in the cost of producing coal which is one result of all this legislation, seems to receive little attention in Parliament, but it has a serious effect on the industries of the country, and on the cost of living.

Mr. Wallace Thorneycroft, the President (1916–17) of the Institute of Mining Engineers, referring to this matter in his Presidental Address states, that the cost of legislation, as specially affecting the coal trade in Lanarkshire, that was passed between 1904 and 1914, and which had to be paid by the steel-plate industry, amounts to 10s. per ton of steel plate (*Trans. Inst. Mining Engineers*, 1917, vol. lii. p. 327).

Truth points to the conclusion that the legislation and governmental interference of the ten years previous to the war has done more to hinder than to help the industry of coal mining.

CHAPTER XV

MACHINERY AT COLLIERIES

Electricity—Exhaust Steam Turbines

MACHINERY is now employed in every operation of coal mining. In the actual getting of the coal from its parent bed, machines are being increasingly used for undercutting the coal seam.

There has been a steady increase, year by year, in the use of machines in the coal face for undercutting the coal seam, during the opening years of the present century. The following figures show the progress that has been made in this respect between 1902 and 1914:—

	No. of Coal-cutting Machines.	Output.	Per cent of Total Output of Great Britain.
		Tons.	
1902 . . .	483	4,161,000	1·8
1914 . . .	3,093	24,274,000	9·1

Mechanical conveyors carry the coal along the coal face, and deposit it in the tub standing on the road adjacent.

The number of conveyors working at the coal face was 377 in 1913, as compared with 268 in the preceding year.

Hauling engines—smaller ones about the workings, see Plate III., and larger ones near the shaft bottom—move the tubs between the coal faces and the shaft. Winding engines draw the coal up the shaft. Hydraulic machinery is sometimes used for removing the tubs from the cages. In the passage of the tubs on the surface to the weighing machine and to the screens and back to the shaft, mechanical creepers raise them to a sufficient height to allow the force of gravitation to do the rest.

The various types of mechanical screens, and cleaning and sorting belts, and coal-washing apparatus all require engines to drive them.

The volumes of air needed to ventilate the miles of underground passages are set in motion by engine-driven fans.

The quantities of water so frequently encountered in underground workings have to be removed by pumping engines.

The miles of underground passages driven mainly through hard rock are driven by the aid of rock-drilling machines.

One result of the war will be a great increase in the engineering equipment of this and other countries. Machinery and mechanical power will be produced on a larger scale and more economically than ever before, and manual labour will be dearer than ever before. Future development in coal mining points to a largely increased use of mechanical appliances.

A greater employment of mechanical power, economically produced, affords the best means of increasing the output per person employed, and so of maintaining a high rate of wages.

"It is only by largely increasing the amount of power used in industry (by two or more times) that the average output per head and as a consequence the wages of the individual can be increased." (See Coal Conservation Committee, Final Report, 1918.)

It is obvious that an economical supply of power which can be efficiently and conveniently transmitted over considerable distances underground as well as on the surface is most desirable for the successful working of a colliery.

Electricity in its recent developments admirably supplies this need.

Compressed air has its special advantage over electricity for work at the coal face, in its avoiding all danger of igniting gas, and in its assistance to the ventilation Also in the low height and cramped space in which coal-cutting machines and face conveyors have usually to work, and in the absence of skilled attendants, there is perhaps more risk of breakdown and stoppage of work with electrical than with compressed air machines. Their relative advantages need to be weighed in each case in connection with the special circumstances.

Where electricity is unsuitable for work at the face, an air compressor driven by an electrical motor may be installed at some little distance outbye from the face.

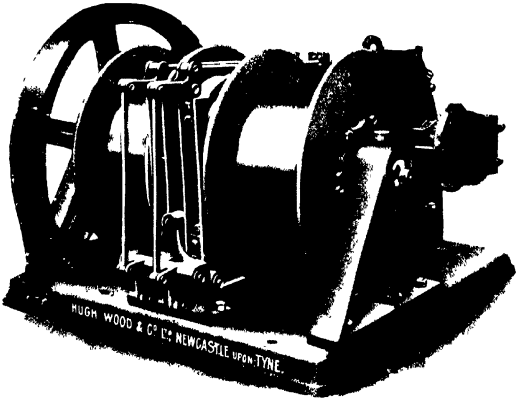
In rock-drilling machines, compressed air still has almost the monopoly.

A careful investigation has been made into the working of compressed air plant at a number of collieries in the United Kingdom by Mr. Sam. Mavor.

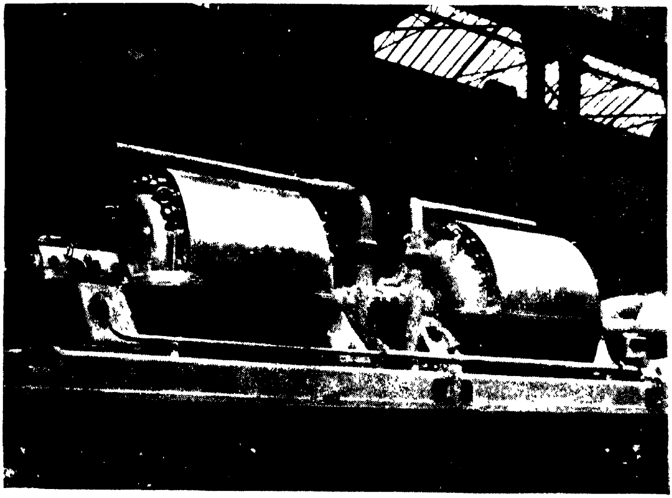
His published results show that there is no department of colliery engineering in which there is more room for improvement and economy.

The safety and apparent simplicity of compressed air has led to gross extravagance and inefficiency in its application at collieries. The contrast with electricity is striking. The general use of measuring instruments—of voltmeters, ammeters, and wattmeters—in connection with electricity, showing what power is being consumed, and enabling faults to be detected at once, has been most valuable in promoting its economical application. With compressed air it has been just the contrary. The general lack of measurement—the absence of pressure gauges and air meters—has led to a deplorable wastefulness in its employment. A fair standard of efficiency is an essential condition of the operation of electricity. If the tension of the current falls much below the normal, an electrical motor will not start, and a cable carrying electricity becomes a source of danger if the insulation is not maintained.

But leakages of air due to defective joints in piping,



ELECTRIC HAULER



[illegible] BRAKE HORSE POWER MIXED PRESSURE TURBO AIR COMPRESSOR

CAPABLE OF DELIVERING [illegible] CUBIC FEET OF FREE AIR PER MINUTE AT A

[illegible] POUNDS PER SQUARE INCH ABOVE ATMOSPHERE

[illegible]

or other faults which might easily be remedied, are allowed to go on, because there is no danger and the loss is undetected and unrealized. Hundreds of pounds per annum are thus thrown away.

Taking the value of compressed air at pressures from 25 lb. to 95 lb. per square inch to be from 1d. to 2d. per 1000 cubic feet of free air, Mr. Mavor gives an instance of a defective joint in a main pipe, which was found to be passing air at a rate equivalent to the value of £500 per annum! (See "Compressed Air for Coal Cutters," by Mr. Sam. Mavor, *Trans. Inst. Mining Eng.*, 1916, vol. l.)

But the increasing use of electricity, which is such a marked feature of colliery engineering at the present day, is due to other causes besides its superior efficiency and convenience. The steam turbine and the gas engine in their recent developments permit the utilization for the generation of electrical current in the most economical manner of two of the chief waste products of collieries. These are exhaust steam from the engines and, in the case of coking collieries, gas from the coke ovens.

Steam-driven winding engines especially, produce as a rule large quantities of exhaust steam, which hitherto has been blown off into the atmosphere or partially utilized for heating the feed water for boilers. Being employed in moving the cages containing the coal tubs up and down the shaft, winding engines necessarily must be constantly stopping and starting, and standing idle for various periods. Of all the engines required at a colliery, they are therefore the most extravagant in their consumption of steam. Central condensing plants have been adopted at the newer or more progressive collieries, but the coming of the low pressure steam and, more recently, the mixed pressure steam turbine has enabled exhaust steam to be utilized for generating electricity in sufficient quantity to perform much of the work of the colliery, and thus to save much of the steam which was previously required. The saving in steam consumption thus effected has been put at 45 per cent, in comparison with 25 per cent to be got by condensing.

Mixed pressure steam turbines may be applied of course also to driving air compressors. A turbo-compressor was installed at New Hucknall Colliery in 1912. Its economy and efficiency were so conclusively demonstrated that a sister plant was put down soon after at Bentinck Colliery, which is under the same management. "This effected a saving of over 25 per cent in colliery consumption, besides giving an ample supply of compressed air, and at the same time relieving the boilers" (see *Proceedings National Association Colliery Managers*, 1915; P. Muschamp, Presidential Address, Midland Branch). But the turbo-air compressor, useful machine as it is when under a constant load and a good load factor, does not equal the turbo-electrical generator in efficiency.

The mixed-pressure turbo-generator is at present the most economical means of utilizing exhaust steam.

Of all the mechanical operations of a colliery, it is for "winding" alone that the superiority of electricity over steam is still in dispute.

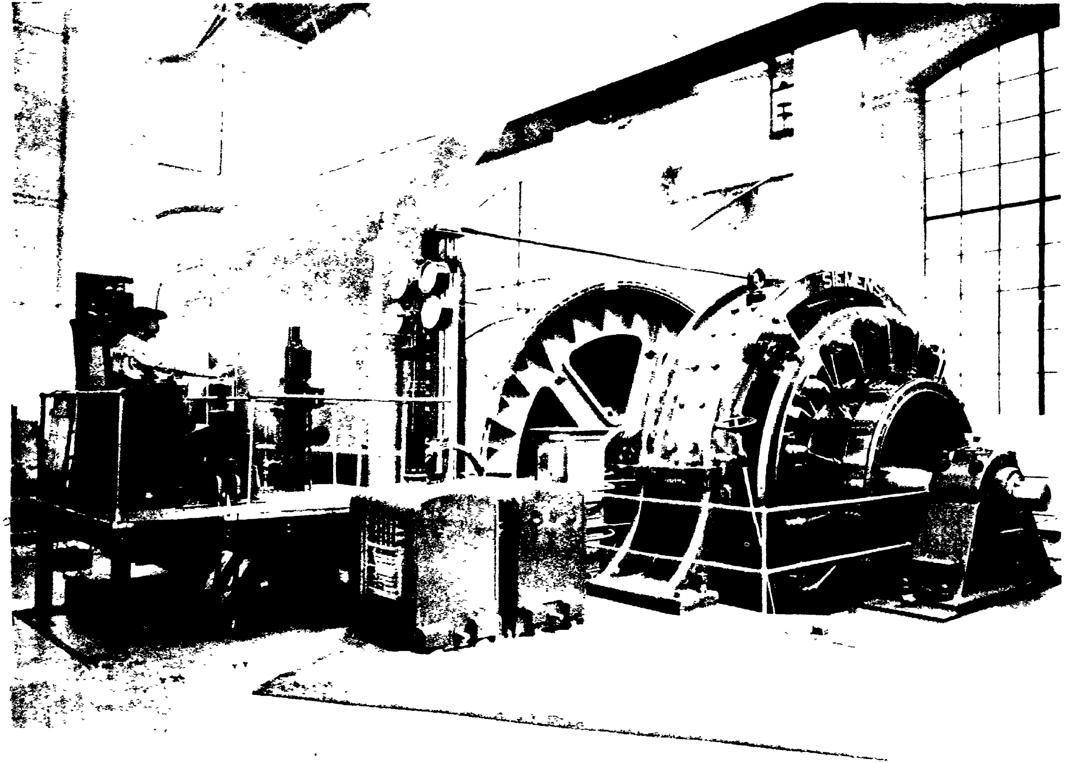
The balance between the two, as applied to "winding," is determined mainly by the cost at which the electric current can be obtained and by the adequacy and the certainty of the supply. At several new collieries the decision has been recently in favour of electric winding, and the whole of the mechanical work of the colliery is being done by means of electricity.

It is claimed as one advantage of electric winding that the winding ropes last longer, and that the maintenance cost of cages, shaft guides, etc., is reduced, owing to the steadier working of electric winders. (See A. C. Nelson, "Points on the Electrification of Collieries," North of England Branch Assoc. Mining Electrical Engineers, Nov. 1917.)

Plate IV. is an illustration of the electric winding engine at Britannia Colliery, South Wales.

The adoption of electricity has been due in some districts, as in the North of England, to the existence of large Electric Power Companies, with whom satis-

PLATE IV



ELECTRIC WINDING ENGINE, BRITANNIA COLLIERY, SOUTH WALES

factory terms have been arranged for the supply of the current.

At the present time the most economical production of power is achieved by central power stations linked up with collieries so as to utilize their waste heat and coke oven gases in the generation of electrical current.

In the North-East Coast district, covering an area of 1400 square miles, there were in 1916 eleven of these waste heat stations in operation.

The power generated is very considerably in excess of that required for the collieries, the balance being delivered into the mains of the power supply company, and used for other purposes. Thus these "waste heat" stations are run continuously at their full capacity with the greatest economy. The coal now being saved by this utilization of waste heat in the North-East Coast area has been stated to amount to 150,000 tons a year. (See Brit. Assoc. Newcastle Meeting, 1916, Mr. R. P. Sloan of the Newcastle Electric Supply Co.)

At their Carville works on the River Tyne, the Newcastle Electric Supply Co. generate electricity at a cost of 0·132d. per unit, of which 0·11d. is the cost of fuel. One of the largest colliery companies in Co. Durham (The Lambton & Hetton Collieries Ltd.) get electricity for all their collieries from this company. They have a generating station, controlled by the Supply Co., where all fuel produced at the collieries which is of little value, such as coal duff, and splint coal, and coke breeze, are burnt in special furnaces, and this is supplemented by a supply of gas from the coke ovens.

Forty-eight million units a year are generated at this station, of which the collieries were using in 1917 about 32,000,000 units. (See *Assoc. Mining Electrical Engineers Trans.*, November 1917.)

Another similar instance, namely, at Blackhall Colliery, Co. Durham, is mentioned in Chapter XVI.

The Newcastle Electric Supply Co. has done a national service in demonstrating how power can be produced and supplied economically over a large area. They are now (1918) supplying about 400,000 horse-power over an area of 1400 square miles.

The increasing cost of boiler fuel makes for the economical advantage of electric winding over steam winding. Inferior qualities of coal, which at one time were unsaleable, are now in demand, owing largely to the spread of Electrical Supply Companies with their central generating stations and improved appliances for burning such coal.

The increasing value of coal stimulates the more economical production of power.

At every new colliery now electricity is adopted as the chief motive power. But at old collieries also, the economies that may be achieved by the employment of electricity have led to the remodelling of many of them.

The question that most often arises for decision is: Will it pay to scrap the existing machinery and replace it by electrical plant?

The possible saving to be effected lies in a smaller consumption of steam, and a reduction in the number of boilers; and consequently a reduction in the cost of boiler fuel, and of labour, and of repairs.

Bearing on this question, some useful figures were given by Mr. Roslyn Holiday in his Presidential Address (delivered October 3, 1914) to the Association of Mining Electrical Engineers. He estimates that on an average a reduction of at least 40 per cent in the number of boilers may be secured by utilizing in mixed-pressure steam turbines the exhaust steam from the winding engines and air compressors, where all other machinery is driven by electric motors. Thus at a colliery using twelve Lancashire boilers of the ordinary type five might be shut off. Taking the yearly cost of a boiler, including coal, water, labour, repairs, and depreciation, at £850, this would effect a total saving of £4250 per annum.

To replace the power of the five boilers, Mr. Holiday considers that a 750 kilowatt[1] turbo-generator of the mixed-pressure type would be required, the capital cost of which, including piping, buildings, transmission, switch gear and motors, he puts at approximately £12,000. The amount saved yearly—£4250—is sufficient to leave a profit, after providing interest and depreciation, both on the plant scrapped and on the electrical plant.

As an instance of what actually is being done in the utilization of exhaust steam at collieries, Silksworth Colliery, near Sunderland, may be quoted.

This is an old and extensive colliery with three winding shafts. There were six boilers underground, and twenty on the surface, and ventilation was by furnace.

The exhaust steam from the three winding engines and from the air compressor, and from the engines about the screens, amounts approximately to 62,000 lb. per hour. This is taken in steel pipes to three receivers, consisting of the shells of old Lancashire boilers 30 ft. long by 7 ft. 6 in. diameter.

Two 760 kw. mixed-pressure turbo-generators have been installed, room being allowed in the power-house for a third set when required.

The guaranteed consumption of steam per kilowatt hour, which was verified by tests at the maker's works, is as follows:—

With Dry Saturated Steam at 110 Lb. above Atmospheric Pressure.

Vacuum.	26 Inches.	27 Inches.	28 Inches.
Full load . . .	27·7 lb.	26·1 lb.	24·6 lb.
Three-quarter load . .	29·3 ,,	27·6 ,,	25·93 ,,
Half load . . .	32·5 ,,	30·6 ,,	28·6 ,,

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[1] A kilowatt is 1000 watts. A watt is the practical unit of electrical power—the rate of working in a circuit when the electro-motive force is 1 volt and the current 1 ampere. One H.P. is equal to 746 watts. A Board of Trade unit is 1000 watts developed per hour, or a kilowatt hour—about 1¼ H.P. for an hour. 1000 kilowatt hours or units=1340 H.P.

With Dry Exhaust Steam at 16 Lb. absolute Pressure:—

Vacuum.	26 Inches.	27 Inches.	28 Inches.
Full load . . .	40·5 lb.	37·2 lb.	33·6 lb.
Three-quarter load . .	43·05 ,,	40·5 ,,	36·65 ,,
Half load . . .	50·9 ,,	47·05 ,,	42·05 ,,

The twenty-six boilers have been discarded, and th whole of the requirements of the colliery are now bein supplied by a new battery of ten boilers 30 ft. long b 9 ft. diameter, working at 120 lb. pressure, with super heaters and Green's economizers. It is estimated that th cost of the electric current from the turbo-generators wil not exceed 0·15d. per unit, including interest on first cos and allowance for depreciation.

The great economy effected in this instance by th utilization of the exhaust steam in turbo-generators i evident, and many similar examples might be given.

But it is well to remember that exhaust steam is a symptom of wasteful working in the engine that produce it, and sometimes it may be more economical to improve th working of the engine, and to reduce its consumption o steam rather than to utilize the exhaust steam.

As some guide to the exhaust steam available at a modern colliery, the following figures may be useful:—

Engines.	Size. Diameter Stroke. Inches.	Exhaust Steam per Hour in Lb.
Winding (twin-cylinder) . .	39·37 by 74·8	11,700
Washery	17·1 ,, 35·37	6,310
Air compressor . . .	19·65 ,, 31·49	6,510
Classifying plant . . .	13·75 ,, 21·7	960
Feed pump	9·25 ,, 11·79	890
		26,370
Deduct 10 per cent for condensation . .		2,637
		23,733

which at a steam consumption of 35·5 lb. per kilowatt hour is equivalent to nearly 700 kilowatts. (See *Colliery Guardian*, February 11, 1916.)

Figures showing the saving effected at a large Scottish colliery by the introduction of a mixed-pressure turbine plant have been given by Mr. H. A. McGuffie in his Presidental Address to the Association of Mining Electrical Engineers (West of Scotland Branch), October 1917. The plant was started on April 13, 1914, and by it the use of five boilers were saved. These boilers consumed 16,000 tons of fuel a year, and required the services of ten firemen seven days a week. The boiler fuel thus saved was put on the market at once, and the economy thus effected, and also in the wages of the firemen and in oil, amounted in the three years ended April 13, 1917, to £15,5[illegible]4.

The cost per electrical unit generated, including all standing and running charges, and a charge for low-pressure and high-pressure steam, averaged for the three years 0·22d. per unit.

CHAPTER XVI

MACHINERY

MECHANICAL POWER REQUIRED AT COLLIERIES AND THE COST OF IT

QUESTIONS which naturally arise are: What amount of mechanical power is required at an average colliery? and What does it cost?

Blackhall Colliery is well known in the North of England on account of the great difficulties which were encountered in the sinking of the shafts through the Permian strata, overlying the south-eastern side of the Durham coal-field. The shafts are situated close to the sea-coast, and immense volumes of water had to be dealt with in sinking them.[1] "The maximum volume of water pumped while the sinkers were working in the bottom amounted to 9150 gallons per minute from the South Shaft from a depth of 84 yards, and 5150 gallons per minute from the North Shaft from a depth of 92 yards, or a total of 14,300 gallons a minute." Sinking with the aid of pumps was continued until the shafts had reached depths of 175 yards and 148 yards respectively, and eventually the water-bearing strata was got through successfully by the "cementation process," the numerous fissures in the strata, from which the water issued, being filled up with cement.

There are four seams to be worked to these two shafts, and the "hanging-on" levels are at depths of 300 yards

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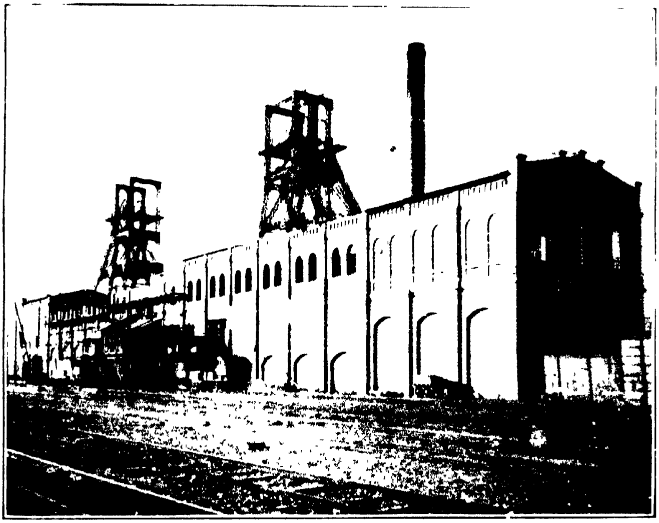
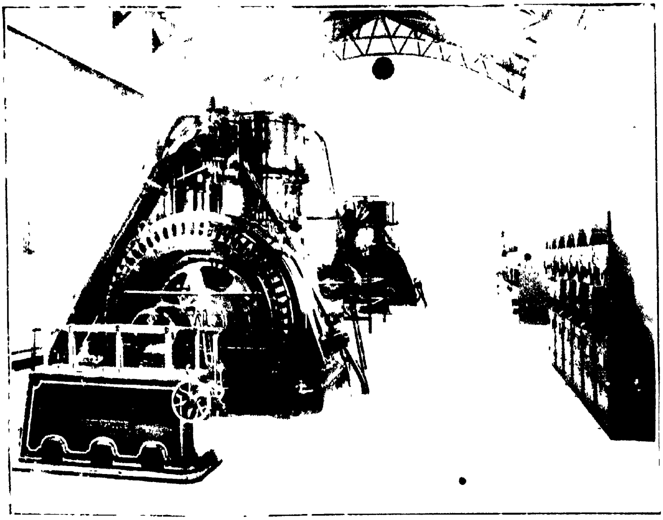
[1] "The Sinking and Equipment of Blackhall Colliery for the Horden Collieries Ltd.," by J. J. Prest and J. Leggat, *Trans. Inst. Mining Engineers*, 1913-14, vol. xlvii.

PLATE V



ELECTRIC WINDING ENGINE HOUSES AND PITHEAD GEAR,
BLACKHALL COLLIERY, CO. DURHAM
[illegible]



TWO [illegible] BRAKE HORSE POWER AIR-COMPRESSORS AND HIGH-AND LOW
TENSION SWITCHBOARDS, BLACKHALL COLLIERY
REPRODUCED BY PERMISSION OF THE INSTITUTION OF MINING ENGINEERS

and 400 yards respectively from the surface. The place is laid out for a production of 750,000 tons of coal a year.

The plant is all electrically driven and is as follows:—

"Two main electric winding engines, each of 700 to 1500 brake horse-power.

"Main high-tension and low-tension switchboards in the power house.

"Two Belliss and Morcom electrically driven air-compressors, each of 535 brake horse-power (see Plate V.).

"Two fan-motors, of 300 and 800 brake horse-power respectively. Duplicate fans are installed.

"Two lighting motor-generators, each of 60 kilowatts, which convert alternating to direct current, for lighting the surface and pit bottom.

"Two 2900/440 volt transformers, each of 200 kilo-volt-amperes, for surface motors under 50 brake horse-power.

'Three electrically driven Sulzer centrifugal pumps, installed in the Low Main seam, each of 700 brake horse-power.

"Screens, fitting shop, and saw-mill motors on the surface.

"One endless-rope haulage motor of 100 horse-power and two 300 horse-power main and tail rope haulage motors underground."

Summing up, this comprises 3000 brake horse-power for winding, 2100 for pumping, 1100 for ventilation, 1070 for air-compressing, and 700 for haulage, a total of 7970 brake horse-power, but this does not include screening, nor machinery in mechanics' shops, nor lighting.

It should be noted, however, that the fan and pump motors are duplicated for security in case of break-down, and that under normal conditions the power required will not average more than 3000 horse-power.

The electric current is supplied from a waste heat plant in connection with the coke ovens of the Colliery Co., in conjunction with a supply from the Newcastle Electric Supply Co., which has a sub-station close to the colliery.

In 1916 the Colliery Co. was generating 2000 kilowatts from the waste heat and surplus gas of its coke ovens, and preparation was being made to increase this to 4000 kilowatts at least.

It is three-phase alternating current at forty periods, 2900 volts. This tension of current—2900 volts—is used for the winding, fan, and compressor motors, and on all motors over 100 brake horse-power. For motors under this size all of which are on the surface, it is stepped down in the transformers to a pressure of 440 volts. Underground there are no motors of less than 100 brake horse-power.

The neutral points of both high-tension and low-tension systems are earthed on the surface.

As regards the cost, Mr. Prest, the general manager, stated in giving evidence before the Coal Commission, that the total cost of the whole undertaking up to date (June 1919) had been £734,000.

This shows a capital expenditure of about £1 per ton of annual output.

With regard to the efficiency of the electric winding, Mr. Prest puts it at 51 per cent, the shaft horse-power hours being 4·8, and the consumption of electric energy 7 units per wind. This is equivalent to 1·45 units per shaft horse-power.

The permanent winding arrangements are not yet, at the time of writing, completed, but it is anticipated that when the colliery is fully developed, the cost of winding will not exceed 5s. per 100 tons raised 1200 feet.

When the additional Waste Heat Station is in successful operation, and the consumption of electric energy averages 25,000,000 units a year, there can be little doubt of the economical advantage of this complete electrical equipment.

With electrical plant the energy consumed can be much more readily and accurately measured than with steam-driven plant. Now that at so many collieries the plant is all electrically driven, it ought to be possible to determine some normal standard of mechanical energy required per ton of coal produced.

A consumption of 25,000,000 units for an output of 750,000 tons of coal is equal to 33 units per ton.

At Britannia Colliery, Pengam, Monmouthshire, the whole of the plant is electrically driven. A large quantity of water has to be pumped, and the coal has to be raised from a depth of 730 yards.

During one week at the beginning of 1917, 10,158 tons of coal were raised, and the number of electrical units consumed was 282,600, which is equal to 28 units per ton.

About 30 units per ton of coal produced seems therefore to be an average consumption of mechanical energy if these two examples may be taken as normal.

At Britannia the 282,600 units were divided over the different engines as follows:—

	Units consumed.	Average Load [1]	Percentage of Total Coal Output consumed.
Pumping . . .	101,480	604	1·11
Compressed air . .	90,150	536	0·99
Winding . . .	68,800	410	0·75
Ventilating . .	15,000	90	0·17
Miscellaneous . .	7,170	43	0·08
	282,600	1,683	3·10

[1] Based on 168 hours a week.

The large amount of power which is required for pumping water at many collieries is evident in this instance. The large consumption of compressed air is due to the number of haulage engines and mechanical conveyors which are in use underground. No horses or ponies are employed underground, the coal being conveyed by mechanical means throughout. The consumption of coal is taken to be 2½ lb. per unit. For the week it was 282,600 units × 2½ lb., or 315 tons. This is equal to

3·1 per cent of the output of coal of 10,158 tons during the week. (See "The Britannia Colliery, Pengam, Monmouthshire," by George Hann, South Wales Inst. of Mining Engineers, 1918.)

Mr. E. M. Hann, the general manager of the Powell-Duffryn Collieries, in giving evidence before the Coal Commission, stated that the number of electrical units consumed per ton of coal raised on an output of 3,800,000 tons was 20, but the winding was only done to the extent of 20 per cent by electrical machines. The collieries being heavily watered, the pumping load was very great, and 35 per cent of the total units generated were absorbed in that way.

In order to obtain reliable information on the important question of how economy may be attained in the application of mechanical power to the various operations of a colliery, a careful and elaborate investigation was carried on continuously—in a way not previously attempted—for a period of eleven months, from October 15, 1911, to August 31, 1912, on a selected colliery in Upper Silesia, the investigation being under the direction of Dr. Karl Schultze of Charlottenberg. A valuable paper giving the results of the investigation has been published, which lays bare the interior economy of the engineering of a colliery, and throws a good deal of light on the power and plant required, and the cost of it. ("Colliery Consumption and Machine Economy at an Upper Silesian Colliery," by Dr. Karl Schultze. Translated by Mr. G. Blake Walker and Mr. Arthur Franks, and revised by the author, *Trans. Inst. Mining Engineers*, 1913–14, vol. xlvii.)

The selected colliery is an old one that has been remodelled within recent years, and may be taken as fairly typical of many other large collieries.

The following facts and figures which are taken from this paper will enable the reader to form some idea of the mechanical operations of a large colliery, of their cost, and of some common causes of wastefulness and loss which ought to be prevented:—

The colliery has an output of about a million tons of coal a year, raised through three winding shafts, 1290 feet, 938 feet, and 900 feet in depth respectively.

The three winding engines and an air-compressor are driven by steam, and the rest of the plant by electricity generated at the colliery.

Boiler Fuel.—To begin with the source of all the power, that is, the fuel burnt under the boilers, a mixture of "slack" and of screen pickings was in use, of poor quality and unsaleable. Its maximum heating value was about 11,000 British thermal units,[1] as compared with 13,500, the figure for the best coal.

Boilers.—There were two ranges of steam boilers, namely, eighteen Lancashire boilers generating steam at an average pressure of 95 lb. per square inch, and sixteen twin (Elephant) boilers working at a mean pressure of 135 lb. per square inch

In the range of Lancashire boilers, over the eleven months, 23,420 tons of coal were consumed, and 127,100 tons of feed-water. The output averaged 3·34 lb. of water evaporated per square foot of heating surface. The efficiency, or the proportion which the heating value (B. Th. U.) of the steam produced, bears to the heating value of the coal consumed was 0·586, which is considered satisfactory as a normal result under the working conditions.

The efficiency of boilers ranges ordinarily from 50 to 75 per cent (0·5 to 0·75). See page 201.

In the battery of twin (Elephant) boilers, during the same period, 55,350 tons of coal were used, and 210,550 tons of feed-water evaporated. The output averaged 5·55 lb. of water per square foot of heating surface, and the efficiency 0·465, a poor result.

These twin boilers were worked under very unfavourable conditions. The feed-water was muddy and caused deposit of sediment, with loss in transmission of heat through the boiler plates, and the boilers were much overdriven, so much so that the firemen were constantly leaving.

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[1] A British thermal or heat unit is the quantity of heat required to raise a pound of pure water 1° Fahr., or, more exactly, from 39°·1 to 40°·1.

The steam from the Lancashire boilers was used to drive the three winding engines; for a bathing establishment; for heating buildings and offices; for pumps; and for a timber-creosoting impregnation plant.

The three winding engines consumed more than half—54 per cent—of the output of these boilers.

There was much waste in connection with the steam used for heating, owing to leakages and to want of traps to eliminate water of condensation.

In connection with this range of Lancashire boilers, there were very heavy losses due to leakage and condensation, amounting on an average to 131·6 tons of feed-water every day.

Their useful work in shaft horse-power hours, heating, baths, boiler-feeding, etc., over the eleven months averaged 3·94 per cent of the heat value of the consumed coal, and 6·50 per cent of the heat value of the produced steam.

In these calculations the relation between heat and work is taken at 2540 British thermal units to 1 horse-power hour.

The twin (Elephant) boilers supplied steam for driving the electrical generators. Eighty-three per cent of it went in this way, another 6·5 per cent in driving the air-compressors, and 4·9 per cent for heating purposes.

The useful work of these boilers was ascertained to be 4·18 per cent of the heat value of the consumed coal, and 8·78 per cent of the heat value of the produced steam.

These results, as is pointed out by the author, Dr. Karl Schultze, are very bad. He states that in the present development of technical science it should be possible to utilize about 21 per cent of the heat generated, and that "in all parts of the colliery, the avoidable losses appear extraordinarily large."

The same remark would undoubtedly apply to a very large number of collieries in this country.

At too many, "a very substantial sum" (to quote from the paper) "is thrown away annually through inefficient machinery and unsatisfactory arrangements, and through an absence of intelligent oversight exercised without intermission over all steam-losses. . . . There is no subject that would more richly repay the application of up-to-date scientific knowledge and painstaking watchfulness and thought."

Figures showing the proportion utilized of the heat units in the coal consumed have been published for the Wharncliffe Silkstone Collieries (Yorkshire). (See "Economical Production and Utilization of Power at Collieries," by F. F. Mairet, *Trans. Inst. Mining Eng.*, 1916, vol. lii.) The investigation was carried out by the National Boiler Insurance Company. Over a period of eighteen days, 839 tons of coal were consumed, calculated to yield 22,251 million British thermal units. Of these heat units, only 387 million, or 1·7 per cent, were utilized in the performance of useful work, the remaining 98·3 per cent being lost.

The consumption of power in the various operations of the colliery is given as follows:—

Power used for	Approximate Horse-power.		Hours per Day in use.	Total Heat Units.
	Average.	Maximum.		Per cent.
Winding . .	100	900	10	14·2
Hauling . .	265	550	10	17·6
Air-compressing .	200	350	24	17·0
Fan . . .	235	—	24	26·2
Other engines .	100	400	12	25·00

"The other engines" included a number of small engines with long pipe connections, and the conditions generally were such as to give rise to a large and wasteful consumption of steam. In fact, the consumption of steam of eleven of these small engines was found to be at the rate of 239·6 lb. per horse-power hour!

At a central electric generating station with efficient engines and a good load factor, an average thermal efficiency is about 8 or 9 per cent of the heat units in the fuel burnt converted into useful work. This is equivalent to a consumption of 2·4 lb. per horse-power hour of a coal of a heating value of 12,500 British thermal units per lb. (See "Fuel Economy," by J. A. Robertson; paper read before Incorporated Municipal Electrical Association June

1917.)[1] 1·7 per cent is of course a very poor result even for collieries. At the Altofts Collieries a similar investigation made by the same people showed that 3·34 per cent (or nearly twice as much) of the heat units produced from the fuel burnt were utilized in work done. In this case only 9 per cent of the heat units were used for winding, which is as a rule the operation most wasteful of steam, and nearly three-quarters of the steam was used in constantly-running engines driving ventilating fans and air-compressors, that is, in the most economical steam users. (See Mr. W. D. Lloyd, discussion on Mr. Mairet's paper.)

In another instance of a colliery with an output of 17,000 tons a week, the thermal efficiency of the plant was 5 per cent. (See Mr. H. F. Smithson, same discussion.)

The "colliery consumption" or the coal used in the operations of a colliery, which thirty years ago used to be commonly about 10 per cent of the output, has now been reduced at the best modern collieries to 1·5 per cent. In the Report (1917) on Electric Power Supply (Reconstruction Committee, Coal Conservation Sub-Committee) the amount of coal used at collieries during 1913 is given as 18,200,000 tons. This makes an average colliery consumption of 6·3 per cent of the total output of that year.

Winding.—To return to Dr. Schultze's investigation. The three winding engines were of the following dimensions:—

Gruschka shaft.—Depth 1290 feet, compound engine 1000 horse-power, cylinders 50 inches and 68 inches diameter, stroke 8 feet. Useful load (weight of coal raised at each wind) 4 tons 18 cwt.

Benjamin ,, Depth 938 feet, engine 600 H.P., 2 cylinders each 44 inches diameter by 6½ feet stroke. Useful load 4 tons 18 cwt.

Mauve ,, Depth 900 feet, engine 300 H.P., 2 cylinders each 33½ inches diameter by 5 feet 2 inches stroke. Useful load 1 ton 4½ cwt.

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[1] It has been stated by Mr. D. Wilson, Technical Adviser to the Controller of Coal Mines, that the thermal efficiency of generation in respect of 421 steam-driven central power stations for the year ended March 1918, with a coal consumption of 7·3 million tons, was 8·5 per cent.

At the beginning of the tests, all three winding engines were connected with the central condensing plant, but later, in order to improve the vacuum of the electric generators, the winding engines were disconnected, and made to exhaust into the atmosphere.

Their consumption of steam per horse-power hour is given as follows:—

Gruschka	engine	34·9	lb.	when working condensing.
,,	,,	45·3	,,	when exhausting into atmosphere.
Benjamin	,,	59·5	,,	condensing.
,,	,,	66·6	,,	exhausting.
Mauve	,,	134·8	,,	when exhausting into atmosphere.

The steam consumption of the Gruschka compound engine is satisfactory, but of the others, much too large.

The losses were due chiefly to leakage in the valve-gear, stuffing boxes, and brake-cylinders of the engines, and also to leakage and condensation in the piping and drain cocks.

Tests were made, enabling the determination of what is termed the "net winding steam," or the steam used for working in the cylinders, exclusive of losses due to stoppages, and this for all three engines was found to average 87·5 lb. of saturated steam per shaft horse-power hour.

The losses due to stoppages were calculated to amount to 69·2 tons of saturated steam daily.

Of thirteen large winding engines at collieries in various parts of England, the estimated steam-consumption per shaft horse-power hour ranged from a minimum of 43 lb. to a maximum of 178 lb., the average of the thirteen being 101 lb. The steam-pressure in the same instances ranged from 20 to 140 lb. per square inch, the average being 91 lb. (See W. C. Mountain, "Utilization of Exhaust Steam," *Trans. Inst. Mining Eng.*, vol. xlvii.)

Recent (1918) tests of a new overhead Kœpe winding plant at Plenmeller Colliery, Northumberland, driven by electricity, showed a steam consumption of about 23 lb. per shaft horse power hour, with the plant working at about half its capacity. The electric generators consumed 17 to 18 lb. of steam per unit. ("Overhead Kœpe Winding Plant at Plenmeller Colliery," by George Raw, *Trans. Inst. Mining Eng.*, 1913, vol. lv.)

These figures show by comparison what a large margin there is for economy in winding engines.

ELECTRICAL PLANT

Coming now to the electrical plant, it consisted of six generators, of a total capacity of 4170 kilowatts.

About 23 per cent of this power goes to some ironworks belonging to the same Company.

Two of the generators are driven by Curtis turbines each of 1500 horse-power; and four by reciprocating engines, two horizontal of 1000 horse-power each, and two vertical of 600 and 400 horse-power respectively.

The efficiency, or the ratio between the useful work done in kilowatt hours and the steam consumption, averaged over ten months, was, for turbo-generator No. 1, 57·6 per cent, and for No. 2, 63·4 per cent.

The vacuum got during this period in the central condensing plant averaged 86·7 per cent.

These efficiencies are not at all good, and show a wasteful consumption of steam due to leakages. The comment made by the author of the paper is one that should be noted by all colliery managers and engineers: "Even with low coal prices, the resulting losses are so great that upkeep of the engines in good order must always pay for itself." Too often at collieries very little attention is paid to leakages of steam at valves and stuffing boxes and pipe connections, on the ground that the boiler fuel costs so little.

The generators produce three-phase alternating current at 550 volts, 50 periods.

This tension is increased through transformers to 2000 volts for many of the motors.

There are in connection with the station 113 motors and 33 transformers. Underground *pumps* absorb the largest proportion of the energy, or 42 per cent of the total.

A large quantity of the water to be raised is due to the hydraulic stowing of the goaves.

Ventilation accounts for 5·06 per cent of the electric energy produced.

There are two Capell fans, one giving 141,200 cubic feet of air per minute under 1·1 inch of water gauge, and the other 88·250 cubic feet of air under 2·65 inches water gauge.

Besides the fans, compressed air-jets are in use for purposes of ventilation, the highest pressure of the air being about 90 lb. per square inch. These air-jets are helpful in clearing away bad gases and fumes in the workings, but their advantages are hardly justified by their extravagant consumption of the compressed air.

3·09 per cent of the electric energy is utilized in haulage. There are fifteen electric locos, three small hauling engines, and two hoists or winding engines underground.

For the locos the current was converted through transformers into continuous current at 120 volts.

The gradients were slight, and the work done by one locomotive was on an average 901,700 foot-tons per shift.

The air-compressor is of 485 horse-power, and is capable of compressing 176,600 cubic feet of free air per hour to a pressure of 90 lb. per square inch. This engine was distinguished from all the others by its high efficiency.

Its consumption of steam per horse-power hour was 17·6 lb. when working in connection with the central condensing plant, and 25·3 lb. when exhausting into the atmosphere. This is equivalent to 0·035 lb. and 0·052 lb. of steam respectively for each cubic foot of free air.

The compressor-plant utilized as much as 10·5 per cent (when working condensing) of the heat units of the steam at the boiler.

Besides the air-jets already mentioned, the compressed air was employed in driving 77 to 103 hammer-drills, to 13 rock-boring machines, 12 to 29 oscillating conveyors, 2 to 3 winches, and 2 pumps.

The length of pipes for conveying the air amounted to 88,500 feet, and the loss through leakage was very heavy, averaging 22 per cent of the total air produced.

The air-jets accounted for another 23 per cent of this total, leaving 55 per cent which was consumed by the hammer-drills, rock-boring and other machines just mentioned.

Each horse-power hour produced by these machines (taken altogether) required 4·65 horse-power hours at the compressor, and 83·6 lb. of steam at the boiler house.

Cost.—The total cost of the plant, most of which has been erected within recent years, before the war, including buildings, steam-pipes, switch-boards, and cables, was £390,085. Of this amount the central electric station, erected in 1909, cost £57,365; the boilers, £30,940 (twin (Elephant) boilers, £18,375, and the Lancashire, £12,565). The three winding engines account for £28,430; the pumping engines, £39,870; and ventilation, including fans, £11,290.

Working costs, including wages, stores, and repairs, are given as follows:—

Steam, 1s. 7d. per ton in the twin (Elephant) boiler plant, and 1s. 1½d. per ton in the Lancashire boilers, on the basis of a steam production of 230,000 tons in the former, and 139,000 in the latter.

Electricity, 0·447d. per kilowatt hour (of British Board of Trade unit).

Compressed air at the compressor, 0·27d. per 35 cubic feet, or 0·36d. per indicated horse-power hour, but at the working point, these costs were raised to 0·709d. per 35 cubic feet and 0·95d. per horse-power hour.

These figures show the extravagance of the air-jets, and the high cost of the air transmission due to leakage.

The working cost of the pumping plant over the whole is given as 0·68d. per horse-power hour, or 0·05d. per gallon of water raised to the surface; of the winding engines (excluding ropes), 1·54d. per shaft horse-power hour; of the locomotives underground, 0·79d. per ton of gross load moved.

Per ton of the output, the cost of the mechanical power is stated to be as follows. It includes interest on the cost of the plant:—

	s.	*d.*
Winning of coal mechanically (face conveyors, etc.)	1	1·81
Haulage (chiefly locomotives)	0	11·16
Winding	0	5·16
Pumping	0	3·57
Ventilation	0	1·28
Other engines	1	1·65
Cost of mechanical power per ton of output	3	0·63

A comparison of this figure with the cost of power at modern collieries like Blackhall, County Durham, and Britannia, South Wales, shows the economy of an entire electrical equipment. where the electrical current can be got at a low figure. Putting it at ½d. per unit, and a consumption of 30 units per ton of coal produced, the cost is 1s. 3d., as compared with the 3s. above.

From this chapter the reader will be able to gather some idea of the machinery and the mechanical power required at a large colliery, and of the great opportunity there is for economy by adopting the best modern appliances.

Mr. C. E. Stromeyer, the chief engineer of the Manchester Steam 'Users' Association, in his memorandum for the year 1915, gives the cost of mechanical power at a modern factory as £12 per indicated horse-power per year, when working about one-third of the full time. This includes capital charges and wear and tear, and fuel at 12s. 6d. per ton. Working continuously night and day, this cost would be reduced to £6 per indicated horse-power per year.

Where waterfalls can be utilized, as in Norway and Sweden, the cost of continuous power production is about 35s. to 50s. per electric horse-power per year.

The cost of a horse-power in ordinary colliery work in the United Kingdom has been put at ½d. per hour, or £18 a year. (See James Hamilton, *Trans. Inst. Mining Eng.*, vol. lv.) No doubt there are collieries that get it for less than this.

Assuming that 3000 horse-power is a normal requirement for a large modern colliery, the cost of £18 a year amounts to £54,000.

These figures show what a large margin there is for economy, and how necessary it is that we should produce power economically in order to maintain our industrial position.

CHAPTER XVII

ECONOMICAL PRODUCTION OF POWER

Gas Engines

THE economical production of power is a vital factor in industrial progress, and is receiving much attention among engineers at the present day. Its importance is apparent when we realize the large amount of power required by the industries of this country. Sir Dugald Clerk, in his Thomas Hawksley Lecture (1915), estimated that altogether, to carry on the industrial civilization of these islands in time of peace, on the scale of to-day, required about 19,000,000 horse-power, and that without coal we could obtain, from available alternatives— chiefly water-power—only 4,000,000. About 80,000,000 tons of coal are consumed yearly in the production of motive power in Great Britain. These figures show the wasteful consumption of over 4 tons of coal per horse-power produced. (See page 105.)

The internal combustion engine using oil or gas is now a serious competitor of the steam engine. The gas engine possesses the inherent economic advantage that it can convert into mechanical power—or brake horse-power—a larger proportion of the heat energy of the fuel consumed than does the steam engine, the comparative figures for the best examples being about 30 per cent for the gas engine and 20 per cent for the steam engine.

The development of the motor car, and the aeroplane, and the submarine has brought these internal combustion engines in their smaller sizes to a high pitch of efficiency, and though in their larger sizes gas engines have hitherto given a good deal of trouble, the difficulties of construction and of running are being overcome.

But Dr. Clerk, who is an authority on the internal combustion engine, admitted in his lecture above mentioned that the difficulties found to accompany increase in its cylinder dimensions limited it to comparatively small units, and that it must be considerably modified before it could equal the steam turbine as a mechanism for producing large powers. Something must be done to introduce the rotary principle in place of reciprocating pistons. The gas turbine is still in the future.

Five thousand horse-power is about the maximum power for which gas engines have been made as yet.

The relative over-all efficiency of different types of power-producing plant, including the steam boiler or gas producer as well as the engine, is something like as follows:—

	Approximate over-all Efficiency.	Equivalent Pounds of Coal consumed per H.P.
	Per cent.	
Small reciprocating, non-condensing engines	5	4–5
Large multiple-expansion condensing . .	6 7	3–4
Large turbine sets	15	1–4
Producer gas	20	0·9–1·1
Oil (Diesel type)	30–33	0·45–0·5 oil

(See Howard Lecture before Royal Society of Arts, Professor John S. S. Brame, January 1917.)

The Diesel oil engine as used in our submarines is the most efficient of internal-combustion engines. It will generate a horse-power hour of mechanical energy from ½ lb. of oil.

In a letter issued August 1918 by the Coal Mines Department of the Board of Trade to all power station engineers, it was stated that, during the year 1917, the highest thermal efficiency[1] shown by any station was 16·25 per cent, and the lowest 1·37 per cent.

The average consumption of coal at the power stations over the whole country was 3·44 lb. per unit, or 2·58 lb. per horse-power (taking the unit to be equal to 1⅓ horse-power).

The best result obtained by any undertaking was 2·026 lb. per unit, and the worst 17·93 lb. per unit.

In this connection it is of some interest to note that in the Fuel Rationing Order of July 1918, 800 units of electricity were allowed as the equivalent of 1 ton of coal, which is equal to 2·8 lb. of coal per unit.

But thermal efficiency is only one element in the economical production of power.

In choosing a Prime Mover it is very necessary to distinguish between the thermal efficiency and the commercial superiority. For industrial purposes the vital point is the actual cost per brake horse-power hour produced, after taking all factors into account, such as capital charges, thermal efficiency, fuel consumption, and costs of lubricating oil, water, labour, and repairs. A paper by Mr. Oswald Wans on "Working Costs of Prime Movers," read before the Institute of Mechanical Engineers on October 19, 1917, shows that the cost of the fuel—whether coal, oil, or gas—has a deciding influence.

"Each type of engine has its particular field of action, in which it can be used with commercial advantage, provided due regard is paid to the local conditions. . . . It is obvious that the commercial superiority of a Prime Mover is not established by reference to its thermal efficiency, but by the local conditions regulating the price of fuel."

A noticeable feature of the gas engine is that it rejects its exhaust at a very high temperature, and its efficiency may be increased by using this exhaust gas for raising steam in gas-fired boilers. These boilers give a higher efficiency than the older type. The Bonecourt gas-fired boiler claims an efficiency of 94 per cent as compared with about 85 per cent for ordinary water-tube boilers; but these efficiencies are seldom realized under actual working conditions (see p. 177).

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[1] The thermal efficiency is the proportion of the heat units in the fuel consumed which are converted into horse-power hours.

In his Presidential Address to the Iron and Steel Institute, the late Dr. Adolphe Greiner, speaking of the gas engine, says: "Look, likewise, at the advantages that may be derived by the utilization of the gases, by combustion, on their leaving the engines: the 500 degrees of heat they carry off with them yield, in appropriate boiler plants, an amount of steam which can be used in machines of different descriptions, or, better still, in turbines. Careful experiments have established that by these means 10 to 13 per cent of the effective energy of the gas engine can be recovered."

This utilization of the exhaust gas from gas engines for raising steam in boilers is being carried out at some collieries. For instance, the Grassmoor Company Limited are using the exhaust gas from four gas engines, each of 500 horse-power, for this purpose. The boilers are 18 feet 7 inches long and 4 feet inside diameter, and are fitted with 96 tubes, 1¾ inches outside diameter. The working pressure is 60 lb. per square inch. The exhaust gases enter the tubes at a temperature of 1180° F., and leave at about 380° F.

The steam-raising capacity of each of these boilers is said to be approximately equal to that of a full-size Lancashire boiler.

At collieries the movement in favour of gas engines has been much assisted by the growing adoption of by-product recovery coke ovens in place of the old beehive ovens. In the regenerative by-product oven a large amount of surplus gas, amounting in some cases to over 6000 cubic feet per ton of coal put into the oven, can be recovered. This gas is available for use in gas engines, and in no other way can it be used so efficiently.

The development of the suction gas producer has brought the gas engine within the reach also of collieries where there are no by-product coke ovens. With the aid of the modern gas producer, unsaleable coal such as is frequently left underground, or thrown into the waste heap on the surface, may be utilized for the production of power in gas engines.[1]

Gas to be used in engines should have a uniform and not too high heating value.

Coke oven gas is rich in hydrogen, containing over 50 per cent of it, and has a heating value running from about 300 to 500 British thermal units per cubic foot, or, say, 400 on an average. The calorific value of producer gas is lower, being about one-fourth to one-fifth of that of coke oven gas, and by mixing the two together a more suitable gas of lower heating value may be obtained. The yield of gas per ton of coal is very much larger in the gas producer than in the regenerative oven, being about ten times as much.

The modern gas producers are constructed to allow of the recovery of the by-products of the coal, and the resulting ammonia and tar are important assets in reducing the cost of the process. The value of the by-products recovered from the coal are sometimes greater than the original value of the coal.

The following estimate by Mr. T. Roland Wollaston may serve as some guide to the cost of producing power by gas engines with a recovery gas plant (see *Trans. Inst. Mining Eng.*, 1914, vol. xlvii. p. 666), at pre-war prices:—

CAPITAL COSTS.

2000 horse-power of gas engines at £6 per horse-power . .	£12,000
27-ton gas-recovery plant at £300 per ton	8,100
Foundations and buildings	3,000
Total capital cost	£23,100

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[1] See paper by Mr. M. H. Mills on "Gas Producers at Collieries for obtaining Power and By-products from Unsaleable Fuel," *Trans. Inst. Mining Engineers*, 1915-16, vol. l.

RUNNING COSTS.

8600 tons of coal at 12s. per ton	5,160
348 tons of sulphuric acid for sulphate plant at 30s. per ton	522
Oil and stores	516
Bags and packing sulphate	116
Labour, twenty men, £70	1,400
Maintenance at 2 per cent	462
Interest and depreciation at 10 per cent	2,310
	£10,486

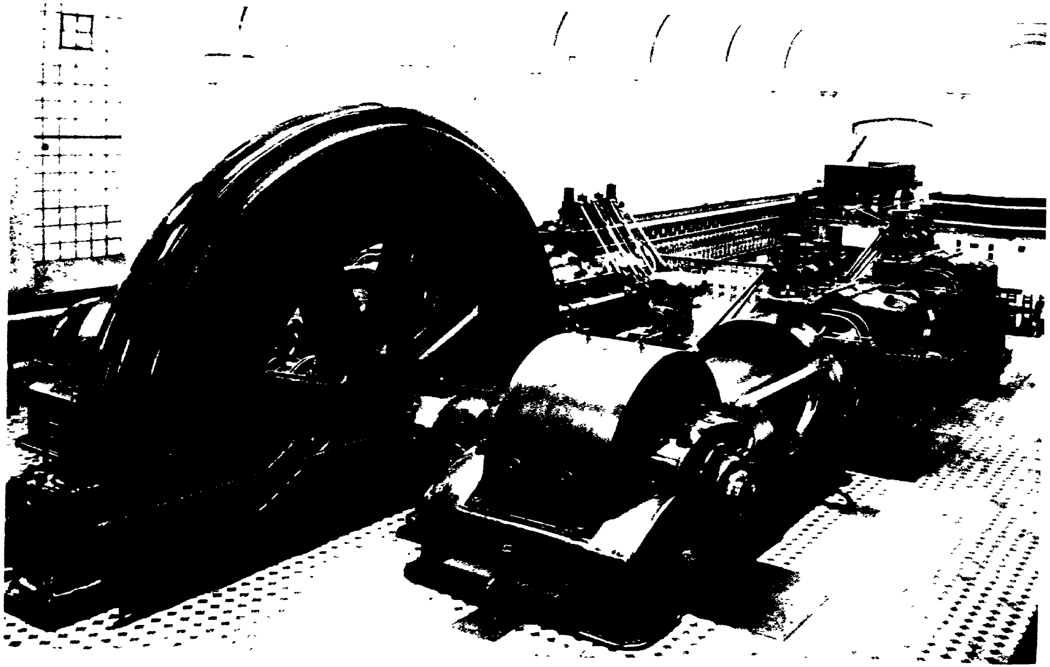
CREDIT.

348 tons of sulphate at £12. 10s. per ton	£4,350	
348 tons of tar at 20s. per ton	348	
		£4,698
	Net running cost per annum	£5,788

Cost per horse-power hour	0·099d.
Cost per horse-power year	£2. 17s. 11d.
Equivalent cost per unit at switchboard	0·148d.

As a good example of the use of gas engines at collieries, the plant at Bargoed Colliery, in South Wales, may be mentioned here (see Plate VI.). It belongs to that progressive company, the Powell-Duffryn Steam Coal Co. Ltd., which in 1913 produced 3,874,000 tons of coal. There are 150 coke ovens at Bargoed, 100 of them being of the Koppers type, and 50 Simplex, which have been erected more recently. Nearly 1000 tons of coal daily are carbonized in these ovens, 600 tons in the Koppers, and 375 tons in the Simplex. About half the yield of gas is used in heating the ovens, but there remains from 4000 to 5000 cubic feet of gas per ton of coal, which is used in gas engines, which are direct-coupled to fly-wheel alternators, running at 100 revolutions per minute There are three Nuremberg gas engines, one a single-tandem of a capacity of 820 kilowatts, and two double-tandem of 1650 kilowatts.

Tests of these engines show that on full load the consumption of gas is 31 cubic feet per kilowatt hour (Board of Trade unit).



They develop at normal full load rating 600 brake horse-power per cylinder.

The analysis of the gas is:—

	Bargoed. Per cent.	Another Example. Per cent.
Hydrogen	56·4	50·2
Methane	20·5	30·1
Carbon dioxide	1·8	3·6
Heavy hydrocarbons	1·9	2·6
Oxygen	0·9	0·3
Carbon monoxide	4·7	7·6
Nitrogen	13·8	5·6
	100·0	100·0

and its heat value is 400 to 410 British thermal units.

To compare with the Bargoed gas analysis is given another of a gas supply from a battery of 110 Otto ovens, which is driving three 500 brake horse-power vertical tandem gas engines, direct coupled to three-phase alternators generating electricity at 450 volts and 50 cycles. The average calorific value of this gas is 520 British thermal units, and the consumption is approximately 39 cubic feet per kilowatt hour. (See "Power from Coke Oven Gas," by Mr. G. Dearle of Grassmoor; paper read before Yorkshire Section of Institution of Electrical Engineers, 1916.)

The average composition of the gases used in gas engines in the North Staffordshire district has been given as follows (see Presidental Address by Mr. Samuel Stonier, Western Section Coke Oven Managers' Association, Dec. 1917):—

Hydrogen	44 to 50	per cent by volume.
Methane	32 to 40	,, ,,
Carbon dioxide	1 to 2	,, ,,
Carbon monoxide	3 to 10	,, ,,
Hydrocarbon gases	2 to 4	,, ,,
Nitrogen	1 to 5	,, ,,
Hydrogen sulphide	1 to 2	,, ,,
	84 to 113	per cent by volume.

For the successful working of gas engines it is important that the gas should be as uniform as possible in temperature and pressure, and that it should be well purified from sulphur and tar.

To return to the Bargoed example: "With an output of 14 million units per annum and a maximum load of 2200 kilowatts, the annual load factor of the gas engine station is 72 per cent." (See paper by Mr. C. P. Sparks on "Electricity applied to Mining," read before Inst. of Electrical Engineers, February 1915.)

This excellent load factor is attained, because the plant supplies the general colliery demands during the day and the main pumping at night.

"By providing high-power pumps and increasing the size of lodge rooms, it was found possible to confine the hours of pumping to from 8 to 12 daily."

The cost of generating electricity at the Bargoed Gas Engine Station for the year 1914 was as follows:—

	Pence.	
Wages	0·03	
Stores	0·03	
Gas	0·08	
Interest	0·10	
	0·24	per unit on a total of 14,260,467 units generated.

(See Mr. Geo. Hann, *Trans. Inst. Mining Eng.* (1916), vol. lii.)

There was trouble at first with cracked cylinders, but this has been overcome by lessening the load, and working the engines at a lower power. By this means the cost of upkeep has been much reduced within recent years. Gas engines will not bear an overload such as steam engines do. A saving in the wear on the cylinders, and pistons, and rods has also been effected by a better purification of the gas from sulphur and ammonia.

In the discussion on Mr. Sparks' paper, the author stated that the gas engines had been working for six or seven years, and that it could now be claimed that complete success had been attained with them. In proof of this the company had decided to add another gas engine set, of double the power of those now in use, the brake horse-power per cylinder being increased from 600 to 1200.

The following schedule of motors belonging to this company is evidence of how largely electricity is now being applied to the industry of coal mining.

	No. of Motors.	Horse-power.
Winding	9	7,530
Pumps above 100 B.H.P.	36	14,490
,, below ,, ...	60	2,120
Fans	14	2,720
Haulages above ground	44	3,800
,, below ,, ...	55	6,370
Screens and elevators	61	1,285
Washery	20	800
Air-compressors	9	1,830
Miscellaneous motors used for surface work .	227	3,855
Total	535	44,800

This 44,800 horse-power constitutes about 60 per cent of the total power requirements of this company. Thus in this case machinery capable of developing about 75,000 horse-power is employed for a yearly output of coal of nearly 4 million tons.

Another pioneer in the utilization of coke oven gas in gas engines for generating electrical power is the Wharncliffe Silkstone Colliery Co. Mr. G. Blake-Walker has published some useful figures of their working results. (See *Trans. Inst. Mining Eng.*, 1914-15, vol. xlix. p. 14.)

If not thus used, the gas would be wasted,[1] and therefore the estimated cost of it may be confined to the expense of purifying it and supplying it to the engines.

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[1] The use of coke oven gas for public lighting is still in its infancy in England, though abroad it has been adopted on a large scale. In 1914 the Corporation of Middlesbrough entered into a contract with Sir Bernard Samuelson & Co. Ltd. for a supply of their coke oven gas to light the town of Middlesbrough. The price paid was stated to be 4d. per 1000 cubic feet, which leaves a large margin in its favour in comparison with the cost of producing gas at most gas works.

In 1916 the whole of Middlesbrough was lighted by this coke oven gas, effecting an enormous economy of fuel.

In 1915 the Leeds Corporation came to an agreement with the Middleton Estate & Colliery Co. Ltd. for a supply of one million cubic feet of coke oven gas daily. The gas is conveyed a distance of 2½ miles through a 9-in. steel main from the coke ovens to the Corporation gas works.

In 1912 the Birmingham Corporation installed a battery of twelve Koppers ovens specially designed for the production of town gas and furnace coke.

Mr. Walker puts this cost at 1d. per 1000 cubic feet.

With gas of 430 British thermal units, the consumption is about 25 cubic feet per horse-power.

The power of the plant is 1340 horse-power (1000 kw.). Fifty ovens of the Simon-Carvés type, thirty-five of them being non-regenerative and fifteen regenerative, supply the gas which produces this power. As the plant is kept running night and day, they have the high load factor of 65·4 per cent.

The load factor is the proportion which the average rate of using power bears to the maximum rate—in this case 100 being the maximum, 65·4 is the average rate; or 654 k.w. out of the 1000 available. The load factor of most colliery power plants is probably between 20 and 30 per cent. The higher the load factor, the better, as the cost is correspondingly reduced. At a load factor of 25 per cent, the cost per unit will be about double what it is at 65 per cent.

"The general effect of the increased load is to minimize the effect of capital and other standing charges, and to increase the thermal efficiency of the power plant—that is to say, to reduce the cost per unit of every item of power cost." (See paper on "Power Costs," by Mr. Wm. B. Woodhouse, *Trans. Inst. Mining Eng.*, vol. xlix.)

The weekly cost of running the plant at Wharncliffe Silkstone Colliery is as follows:—

	£	s.	d.	d.	
Gas, 3,679,200 cubic feet at 1d. . . .	15	6	3	0·033	per unit.
Attendance, enginemen, etc. . . .	10	11	9	0·023	,,
Cooling water, 336,000 gallons at 7d. per 1000 gallons	10	0	0	0·022	,,
Lubricants and stores	6	18	6	0·015	,,
	42	16	6	0·093	per unit.

The total weekly output is 109,872 units.

The cost of upkeep—that is, of repairs and renewals—of the gas engines during 1914 amounted to £630. 10s., which, on the yearly production of 5,493,500 units, is equal to 0·027d. per unit.

The cost of a gas engine of 1400 horse-power is put at £5. 10s. per horse-power, or £7700. To this is added 50 per cent for foundations, engine house, cooling water-tank, circulating pumps, etc., making the capital outlay £11,550. Taking depreciation at 12½ per cent, the yearly charge on this account amounts to £1443. 15s., or 0·066d. per unit. The prudent provision of a third engine in reserve increases the capital expenditure by 50 per cent, and brings up the cost of depreciation to 0·099d. per unit.

The total cost therefore is as follows:—

	d.
Cost of gas (surplus) . .	0·033 per unit.
,, running . . .	0·060 ,,
,, upkeep . . .	0·027 ,,
Depreciation of plant . .	0·090 ,,
Total	0·219 per unit.

Mr. Blake-Walker estimates the cost of a steam turbine to do the same work to be:—

	d.
Boilers—fuel 24 cwt. per hour for 1000 units . .	0·115 per unit.
,, labour stoking (3 shifts, 2 men) . .	0·020 ,,
Engine (turbine) enginemen (3 shifts, 1 man)	0·010 ,,
Stores	0·005 ,,
Upkeep	0·017 ,,
First cost and depreciation (10 per cent) on £10,000	0·060 ,,
Total	0·227 per unit.

It will be noticed that the cost of upkeep of the steam turbine is much less than that of the gas engine.

Gas engines not driving electrical generators but coupled direct to colliery machinery have been in use for a good many years with complete satisfaction. An interesting example of this at Malton Colliery, Co. Durham, has been described by the late Mr. T. R. Lonsdale (see North of England Branch of National Association of Colliery Managers, May 1915). This colliery has by-product ovens, from which the gas is derived. The first experience of using the surplus gas for motive power was in 1905 in a very small engine in the fitting shop. In 1907 at a Day-drift about a mile distant from the ovens, more power being required for hauling, an 80 horse-power single cylinder gas engine was installed. It was coupled direct to the gear wheels driving the haulage drums, which are arranged for the main and tail rope system, the connection being made through a friction clutch. The gas engine is kept running continuously, and the drums are connected and disconnected through the clutch.

The gas is brought from the coke ovens to the engine—a distance of about a mile—through a 3-inch cast-iron gas main. To purify it from sulphur it is passed through iron oxide purifiers. The consumption of gas at full load averages 16 cubic feet per brake horse-power per hour. During seven years that it has been in constant use, there has been only one stop, and that of only four hours' duration, due to a hot bearing. The number of renewals has been limited to one or two small parts in connection with the ignition arrangements. It was examined by the Insurance Company's Inspector in 1915, and his report shows that there has been surprisingly little wear and tear. "The engine will run many years before either the cylinder or piston requires renewing." The experience has been so satisfactory that two more gas engines have been installed at another Day-drift which is about 2 miles distant from the coke ovens. One of these engines—60 brake horse-power, single cylinder—drives a ventilating fan, and the other—160 brake horse-power, twin cylinder—drives haulage drums for a main and tail rope haulage system.

A determination of the most economical method of producing power at a colliery is by no means a simple matter, so many factors call for consideration. Much depends on the existing conditions. The following are some points worth noting.[1]

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[1] In these remarks the writer wishes to acknowledge his indebtedness to the instructive paper by Mr. W. B. Woodhouse already referred to.

A central generating plant producing all the power required is more economical than a number of separate generators. With separate generators, each must be equal to the maximum load of its particular work of pumping or hauling or winding or whatever it may be. The load of each separate operation varies much and frequently, and when one is at its maximum, another may be at its minimum. Thus by drawing the power for all from one central source, the maximum power required at one time is reduced.

Also the load factor of a central plant will be better than that of separate plants. The central plant will be working more regularly at or near its full load, and thus at its highest efficiency.

Moreover, a large plant relatively to its size consumes less steam than a small plant, and therefore is more efficient and economical for this reason also. Again, the first cost of machines in proportion to their power is less as their power is larger. For any given power one large machine costs much less than two or more smaller ones producing together the same power. The gas engine is an exception to this rule.

On the other hand, it is often advisable to divide the power plant into two or more units, because this permits of a smaller spare plant which must be provided against the risk of break-down, and also allows better for increasing the plant as the colliery extends and needs more power. Each unit of plant where there are more than one should be of the same size.

Of working costs, the biggest items are capital charges and fuel consumption.

Capital charges should include a fair allowance for interest on the first outlay, and for the deterioration of the plant, which sometimes is very rapid and soon destroys its efficiency; and to cover these charges fully, some allowance should be made also for scrapping and replacing the machinery as it becomes obsolete and improved plant is available.

Mr. Oswald Wans ("Working Costs of Prime Movers," Institution of Mechanical Engineers, October 19, 1917) considers that: "The depreciation rate should spread the expenditure burden over a reasonable number of years and permit in good time of the removal of the power plant in favour of a more modern type, should the developments in later-day practice render the running costs comparatively high. It is considered that a uniform annual rate of 8 per cent, equivalent to twelve and a half years' service, fulfils these conditions. . . ."

The amount written off annually under this head may be therefore 8 per cent of the capital expenditure. This is independent of any allowance for wear and tear, or for insurance against breakages, or for interest on the capital expenditure.

In considering the cost of fuel consumption, it should not be overlooked that the different types of machine—the steam engine, the steam turbine, and the gas engine—differ in the economy of their consumption under variations and reductions of working load. This is important because at collieries they work frequently under a fluctuating load. In each of them a certain proportion of the consumption is due to resistances in the engine itself apart from the working load. But this "initial consumption" at no load and independent of the load, is larger in some than in others.

Mr. Woodhouse (see *Trans. Inst. Mining Eng.*, vol. xlix.) gives figures and diagrams "showing the initial consumption" of a 100 horse-power non-condensing engine to be 22·2 per cent of its consumption at full load. Of a 5000 kilowatt turbine working with high pressure superheated steam and a good vacuum, he states it to be 15 per cent; and that of an exhaust steam turbine or gas engine to be more than double this, namely, 30 to 40 per cent.

He gives the following figures of the relative fuel consumption at varying loads of the steam engine, the steam turbine, and the gas engine, 100 being taken as the consumption at full load in each case.

Load.	Steam Engine.	Steam Turbine.	Gas Engine.
Full	100	100	100
Half	122	115	135
Quarter	167	145	215

The steam turbine works the most economically of the three under reduced loads, and the gas engine the most extravagantly.

The vacuum maintained in the condenser has a very important influence on the efficiency of steam turbines, more especially of exhaust steam turbines. It has been stated that a fall of 1 inch from 27 to 26 inches in the vacuum of an exhaust steam turbine increases its consumption of steam by 20 per cent.

High-pressure steam turbines are now constructed to give a steam consumption at full load of 10·2 lb. per kilowatt hour. This is equal to 7·65 lb. of steam per horse-power hour.

Another point to be considered is the auxiliary machinery (circulating and air pumps and condensing arrangements) and the power required to drive it. On this point the gas engine has the advantage of the steam turbine.

The steam boiler affords large scope for economy in fuel consumption, its range of efficiency being as wide as from about 40 to 80 per cent.

Owing largely, no doubt, to the fact that coal at collieries is abundant and relatively cheap, there is too often much carelessness and wastefulness in its use as boiler fuel.

One of the numerous committees of the Ministry of Reconstruction investigated this matter.

In their report (August 1918) it is stated that the consumption of coal for boilers at collieries in Great Britain during the year 1913 was on the average 6·8 per cent of the output of coal. Certainly there is room for a considerable saving of fuel under this head.

A careful and scientific investigation of seventy-five "typical" boiler plants at collieries situated in various districts—South Wales, Lancashire, Yorkshire, Derbyshire, Nottinghamshire, and Forest of Dean—carried out by Mr. D. Brownlie (see "Coal Saving at Collieries by Economical Steam Raising," by D. Brownlie, *The Colliery Guardian*, March 1, 1918), showed an average thermal efficiency of only 52 per cent, or, in other words, nearly half of the coal consumed to raise steam was wasted.

The average amount of water evaporated per boiler per hour was only 437 gallons, whereas with proper care and management 800 gallons an hour can be turned into steam in similar boilers—i.e., Lancashire boilers 30 ft. by 8 ft. 6 in.—with coal of similar quality.

Taking the price of the coal at 12s. a ton, the average cost in coal to evaporate 1000 gallons of water was 10s.

At a medium-sized colliery using, say, 30,000 tons of coal a year, the coal bill at 12s. a ton amounts to £18,000. Thousands of pounds of money and thousands of tons of coal a year might be saved by a more careful and scientific management of the boiler plant at collieries.

For the proper management of a boiler plant regular and accurate measurements are essential. A record should be kept of the water evaporated, the coal consumed, the ashes removed, the temperature of the feed water, the temperature of the escaping gases, and the CO_2 they contain, etc. etc.

(Valuable information on boiler economy at collieries is contained in "The Economical Use of Coal," by T. J. Nelson, *Trans. South Wales Branch of Association of Mining Electrical Engineers*, December 1918.)

A valuable aid to boiler economy is the use of CO_2 (carbon dioxide) recorders to ascertain the amount of this gas present in the gases escaping into the chimney. The proportion present shows whether the fuel under the boiler is being properly burnt. With thoroughly efficient combustion this proportion should be 12 per cent or more.

A common cause of extravagance and waste is the overpressing of the boilers when there are too few to supply the steam required of them. The greatest source of loss in the general working of boilers lies probably in the heat carried away by the flue gases, and this loss is largely increased by reductions or variations of the load. A steady load is a most valuable factor in the economical working of any steam plant.

The quality of the coal used is an important matter, as is shown by the following tests made by Mr. F. F. Mairet (see "Economical Production and Utilization of Power at Collieries," by F. F. Mairet, *Trans. Inst. Mining Eng.*, 1916, vol. lii.): With a battery of six Lancashire boilers, hand fired with fuel of 11,840 British thermal units, 6550 units or 55·3 per cent were transferred to the water, and with a similar set of five boilers, working under similar conditions, but fired with a poorer fuel of 10,370 British thermal units, the heat transferred to the water was only 4132 units or 40·4 per cent. In the latter case the loss of heat due to excess air was 27·4 per cent as compared with 16·6 per cent in the former, showing the tendency with the poorer fuel to force the draught of air in order to improve combustion. The water evaporated per pound of fuel as fired was 6·06 lb. with the better class of fuel, and 3·88 lb. with the other.

The results given by a plant when tested under favourable conditions should not be accepted as showing what it will do under actual working conditions. Estimates of cost based upon test conditions are likely to be misleading. Probably 50 per cent is not too much to allow for the difference. In other words, the fuel consumption of a plant working at a colliery is usually double or more of what it was under tests at the maker's works.

Mr. Woodhouse supplies the following example of a new and up-to-date plant working under favourable conditions—a 1500-kilowatt steam turbine and alternator;

water tube boilers fitted with automatic stokers, raising steam at 150 lb. pressure per square inch, and superheated to 150 degrees Fahrenheit; fuel, Yorkshire slack of a heating capacity of about 12,500 British thermal units per lb.; vacuum 28·5 inches; maximum load, 1000 kilowatts, and a load factor of 25 per cent.

The total amount of coal burnt and the output of electricity were observed and recorded for periods of six hours over several weeks of working. The consumption of coal per kilowatt hour (Board of Trade unit), calculated on test figures, was 2·5 lb., but the actual consumption was 3·1 lb. at full load, and under the ordinary working conditions of reduced and fluctuating load, it was practically 5 lb. of coal per kilowatt hour.

In this case, where all the conditions were favourable, the fuel consumption was doubled, and certainly at many collieries the increased consumption due to working conditions must be even greater than this.

A steady load and a good load factor are most valuable elements in the economical production of power.

CHAPTER XVIII

COLLIERIES AS AN INVESTMENT FOR CAPITAL

THE industry of coal mining—it is well to remember—like other industries, depends for its existence and for its continuance upon its capacity to return a profit on the capital invested in it. No industry of any kind can be carried on without capital. The more capital there is available, the better is it for labour. But this does not imply that the entire control of industry by the owners of capital is the best possible industrial system! It is the right use of capital that is essential.

Before any profit at all can be earned, a large amount of money, amounting sometimes to hundreds of thousands of pounds, has to be spent on sinking shafts and erecting machinery. The amount of this expenditure, and the length of time before any return on it can be made, depends mainly on the depth of the shafts to be sunk, and on the difficulties encountered in the sinking, especially on the quantities of water met with. It has been estimated that on an average about £2,000,000 are spent annually on sinking and equipping shafts in the United Kingdom.

There are a good many different estimates of the amount of capital invested in collieries. In 1893, Sir George Elliott, a colliery manager and owner of much experience, put it at 15s. 3d. per ton of annual output of coal. Mr. G. P. Bidder, Q.C., writing in the *Nineteenth Century Magazine* of May 1895, estimated the capital required at about 10s. per ton. This is the lowest estimate ever put forward, and has been adopted by the advocates of nationalization. Twenty years ago it may have been near the mark, but certainly now it is quite inadequate.

During the last twenty years deeper shafts have been sunk, the workings are more extensive, and the mechanical equipment of collieries has been greatly enlarged.

The capital required for many modern collieries is nearer 20s. than 10s. per ton of output. Blackhall Colliery, County Durham, is an instance in point (see page 174).

The capital per ton of output of the Limited Liability Colliery Companies in the Ruhr district in Westphalia before the war, having a total output in 1913 of 110,765,000 tons, was rather over 20 marks—which is just about 20s. a ton (see *Colliery Guardian*, May 2, 1919).

Dr. J. C. Stamp (in his "British Incomes and Property," published in 1916) estimates the capital value of coal and other mines at £179,000,000 with a range of doubt—plus or minus—of £18,000,000.

In engineering works the capital is estimated to be £200 per individual employed. (See Mr. Gerald Stoney, Presidential Address, British Association, Engineering Section, Newcastle Meeting, 1916.)

Putting it at 15s. a ton, the capital value on an output of 280,000,000 tons—in 1913 the output exceeded 287,000,000 tons—would be £210,000,000, or about £200 per person employed.

Allowing 3 per cent, or a period of about thirty-three years, for the redemption of capital, the cost per ton under this head alone, apart from any interest for the use of the capital, will be 5·4d. (3 per cent on 15s.)

Any general statement about the return received on the capital which is invested in collieries is apt to be misleading. The truth is, that at some collieries it receives a very large return; at some, much capital is altogether lost or remains unremunerative for years; and there are many collieries which pay well occasionally when the selling price of coal is high, but in normal years do little more than pay their way. The coal trade is subject to extreme alternations of prosperity and adversity.

With favourable natural conditions, plenty of working capital for proper development and for tiding over lean years when the selling price of coal is low, and—most essential perhaps of all—capable and far-seeing management, good results may be achieved. An ample reserve of capital is required. Underground conditions are always uncertain, unforeseen sources of expense often arise, labour disputes are chronic, legislation constantly lays new burdens on the industry, and the coal market is very variable.

Much money is lost in new enterprises from the available capital being insufficient (owing to unforeseen difficulties) to bring the concern to the profit-earning stage. The original adventurers lose their money, and the purchasers at a forced sale reap the benefit, making a large profit on the low capital expenditure with which they purchase the property.

Fluctuations in profits follow necessarily fluctuations in selling price. Dr. J. C. Stamp (in a paper read before the Royal Statistical Society, 1918) shows that rise in price in the coal-mining industry has increased profit in a lesser degree than fall in price has reduced profit.

Fluctuation in price has had a much greater effect on profit than fluctuation in output.

Evidence of how greatly profits vary at different collieries in the same coal-field is forthcoming from the report dated June 25, 1915, of a firm of chartered accountants, made at the request of the Monmouthshire and South Wales Coal Owners' Association. Seventy-nine firms were included, with an annual output of 33,983,829 tons and employing 121,722 men. These firms represent by far the greater proportion of the steam-coal trade of South Wales.

The report covers the working of the collieries for the year ended December 31, 1914 (or near date of the end of the financial year of each firm).

Of these seventy-nine firms, twenty-nine were working at a loss or at no profit at all on their ordinary capital; twenty-five were earning a profit of less than 1s. a ton, and twenty five were earning more than 1s. a ton.

Of the output of nearly 34 million tons, 6,711,175 tons—or 19·8 per cent, close upon one-fifth of the whole—were produced at a loss or at no profit; 9,401,128 tons—27·6 per cent—at a profit of less than 1s. a ton; and 17,871,526—52.6 per cent—at a profit of 1s. a ton or more.

Five firms producing 4,802,074 tons made profits of 2s. 6d. and upward.

These were the results in a year (1914) when trade was good, and with a coal of special value and of world-wide reputation—Welsh steam coal.

They may be taken as fairly typical of the wide difference in the financial results of colliery working in the United Kingdom. A few collieries make large profits, but many make losses or no profit at all.

The figures also show that the large concerns with large outputs are generally the most successful. Five firms producing 4,802,074 tons made large profits, but twenty-nine firms producing 6,711,175 tons made losses or no profit.

People sometimes speak of "the huge profits of the coal-owners," and it is true that huge profits are sometimes made, but it would be equally true to speak of their huge losses, because huge losses are sometimes incurred, but nobody cares to talk about losses. Coal-owners nowadays are to a large extent limited liability companies, with thousands of shareholders holding varying amounts of shares, and many of them possessing only small means.

There are not many colliery companies that have paid an average yearly dividend of 10 per cent to their ordinary shareholders over a period of twenty years. Every colliery is a "wasting" asset, the coal being in continuous process of exhaustion, and 10 per cent cannot be considered an exorbitant return on the money invested.

But the industry of coal mining is sharing the general tendency of industrial enterprise to return more in wages and less in interest on capital.

This tendency is not confined to the United Kingdom. In the U.S.A. an investigation conducted by a special committee of the National Civic Federation formed the subject of a (1915) communication to the *Statist*, by Mr. W. M. Ackworth, wherein it is stated that while the average annual wage in manufacturing districts has increased from $247 to $518 (£51 to £107) in sixty years—an increase of over 100 per cent—the normal rate of interest has decreased one-fourth. Of the total wealth produced, a larger share is going in wages and salaries, and less in interest on capital.

Prudent investors may be inclined to agree with the opinion of Mr. Nathaniel Clayton, an eminent citizen of Newcastle-on-Tyne, who, in his examination before a Committee of the House of Commons in the year 1800, stated:

"I have lived my whole life in a coal-mine country. I have possessed the means, and have had frequent opportunities offered me of adventuring in speculation of this nature. I have ever declined doing so upon this principle—that the average profits resulting from these adventures were inadequate to the employment of so much capital as they required and to the risk attending them."

This is an extract from a paper on "Capital and Labour employed in Coal Mining during the past Two Hundred Years," read by Dr. J. B. Simpson before the members of the Newcastle Economic Society on March 9, 1898. In this paper Dr. Simpson brings forward much evidence about the average return on capital invested in coal mining, which leads to the general conclusion that it is not more than 5 per cent:

"This . . . . seems an inadequate return; especially when we consider that at least 1½ or 2 per cent should be set aside to provide a redemption fund to meet the loss of capital which ensues at the end of the lease."

A similar conclusion is reached in an article in *The Iron and Coal Trades Review* of May 23, 1913, discussing a reply given just previously in the House of Commons by the Secretary of the Treasury to a question concerning colliery profits in the federated area.

The approximate distribution of the gross selling value of all the coal produced in the federated area in the four years 1908–11 was estimated to be as follows:—

Labour . .	£121,000,000	69·4 per cent.
Materials . .	28,000,000	10·0 ,,
Royalties, rates, etc. .	13,000,000	7·4 ,,
Profits . .	12,500,000	7·2 ,,
		100·0 per cent.

But out of this sum of 12½ millions of profits there has to be paid the cost of new plant and machinery, and of extensions, so that the average gross return on capital does not appear to be more than 5 per cent.

It is the prizes—the large profits—made sometimes that attract the necessary capital and stimulate enterprise.

In comparison with other industries, coal mining returns less to capital and more to labour.

In a book called "The Division of the Product of Industry: An Analysis of National Income before the War," Dr. Arthur L. Bowley (Professor of Statistics in the University of London) gives figures as follows:—

In coal mining 75 per cent of the product goes in wages, 3 per cent in salaries, and 22 per cent in profits, interests, rents, royalties, and advertisements, the corresponding figures for other industries being 58 per cent, 10 per cent, and 32 per cent.

The estimated cost of producing 192,000,000 tons of coal during the year ending July 16, 1920, which has been supplied by the Government to the House of Commons, allows for labour £210,250,000, and for owners' profits £12,500,000, out of a total cost under all heads of £281,250,000. According to these figures labour gets 74·7 per cent of the total cost, and capital only 4·4 per cent.

CHAPTER XIX

RESCUE WORK

THE deadly gases which fill the roadways of a mine after an explosion or on the occasion of an underground fire, are the chief obstacle to the rescuing of any men who may be left alive in some district of the mine which has not been affected. It is the after-damp, of which carbon monoxide (CO) is the most dangerous constituent, which kills most of the victims of colliery explosions, and, avoiding this, men may sometimes live for a considerable time, though unable to reach the shaft. The main thing to be done immediately after an explosion is to restore the ventilation, so as to bring fresh air to any men who may be left alive. Rescue work has become associated latterly with the use of self-contained breathing appliances, but the rescue of survivors and the recovery of a mine after an explosion has on many occasions been carried out most efficiently by trained miners thoroughly acquainted with the mine and yet before the days of breathing appliances. A valuable aid to this work within recent years has been the use of mice or small birds, such as canaries or greenfinches, to show the presence of carbon monoxide, as first suggested by Dr Haldane.

A very small quantity of this gas will soon render a man unconscious, and it cannot be detected by its effect on lamps or by its smell. But small birds and mice show the consequences of breathing it, sooner than men, and thus a rescue party carrying with them in a cage a couple of small birds receives warning in time to escape.

But it is worth noting that there are poisonous atmospheres which affect men sooner than mice.

In the recovery of Norton Colliery in North Staffordshire after the explosion there in 1912, it is recorded that men were affected and safety lamps were extinguished whilst mice and canaries remained quite active. (See *Trans. Inst. Mining Engineers*, vol. xlvi.)

A deficiency of oxygen in the atmosphere breathed causes collapse in men in about the same time as it does in mice and birds. (See U.S. Bureau of Mines Technical Paper No. 122, 1915.)

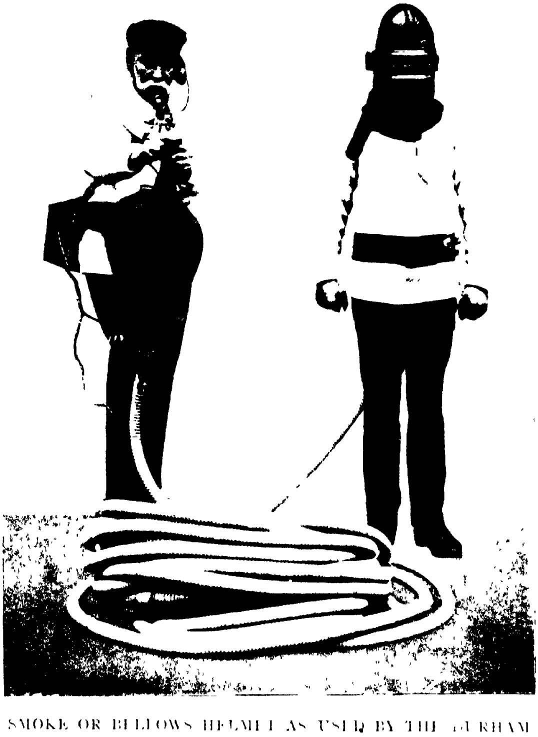
Whenever it is possible, rescue work should be done without the use of breathing apparatus, which necessarily much impedes the movements of the wearer. It is a general rule of the Durham and Northumberland Collieries Fire and Rescue Brigade that in practical rescue work, before using breathing appliances, a preliminary inspection should always be made with the aid of birds.

Underground fires afford more frequent calls on the services of rescue brigades than do colliery explosions.

These fires are of various kinds, and require different treatment. A good many occur in underground engine houses and stables where the burning timber causes dense fumes and smoke. These fumes generally back out-bye against the ordinary air current, and prevent men from reaching the seat of the fire. In dealing with any fire, the idea which used to prevail was that access of air to it should be prevented, but recent practice has discredited this method of treatment of fires such as are apt to occur in engine houses or with haulage apparatus.

Mr. Mills, the chief officer of the Durham and Northumberland Brigade, informs the writer that during the last few years he has dealt successfully with five such fires in the Northern coal-field as follows:—

Instead of stopping the air current, the first step has been to increase it so that it may be strong enough to drive back the smoke and enable the brigade men to reach the fire and deluge it with water. They carry a portable



SMOKE OR BELLOWS HELMET AS USED BY THE DURHAM AND NORTHUMBERLAND RESCUE BRIGADES

pump which, worked by a couple of men, will throw a jet of water to a height of 30 feet.

In no case have the men worn breathing apparatus, though they have sometimes been working with the fire burning at their feet.

They are all right so long as the air current is strong enough to carry away from them all the smoke and fumes. By this method all these fires have been got under in a short period, usually two to three hours.

Where there has been no natural water supply available near the seat of the fire, water has been brought in the colliery water tubs with all the expedition possible.

Of course there are fires, such as deep-seated gob fires, which cannot be extinguished by water, and which should be dealt with by digging out the burning material.

Much admirable and efficient rescue work has been done in coal mines by men without any breathing apparatus, but an appliance enabling the wearer to penetrate into an irrespirable atmosphere is a great boon. Such an apparatus must be absolutely reliable, or it becomes a death-trap, and it cannot but restrict and hamper the movements of the wearer. A good test of its safety is to try it on a man entirely submerged under water, and it is not quite safe unless it can stand this test.

In their present stage of development there is a good deal of truth in the gibe: "No rescue apparatus is good, but some are worse than others." There can be little doubt, however, that the great difficulties which surround the designing and making of a thoroughly reliable breathing appliance will be overcome before long.

"The defects, in our opinion, are mainly in matters of detail, and if improved in the way we suggest in this Report, the apparatus should be capable of doing rescue and recovery work under the most trying circumstances" (First Report of Mine Rescue Apparatus Research Committee, 1918).

For more than fifty years past, attempts have been made to design such an appliance, and latterly substantial progress has been made. A brief historical résumé shows the steady development that has taken place.

In 1853, Mr. T. Y. Hall of Newcastle-on-Tyne described before the North of England Mining Institute (see *Trans.*, vol. ii.) "a simple, practical, and commodious plan for enabling a man to penetrate, without delay, to great distances . . . and to act freely in underground excavations filled with dangerous gases," but besides an air-tight dress, this simple plan required the laying down permanently of pipes from the downcast shaft along the main galleries of the mine into the workings and back to the upcast, and the constant circulation of a current of air through them!

In 1875 an apparatus for exploring in the presence of dangerous gases, invented by the Brothers Denayrouze, was tested practically at a meeting of the same Institute (see *Trans.*, vol. xxiv.) by the wearer descending into a cellar, connected with the Institute building, filled with noxious gas, and remaining there some time.

In 1881, after a big explosion at Seaham Colliery, County Durham, the Fleuss apparatus[1] was used in exploring the mine. This was the earliest of the modern portable self-contained breathing appliances, and in a much improved form—the Proto—it is still one of the best of them. It supplied oxygen, at a pressure in the cylinder of 250 lb. per square inch, and provided for the purification of the expired air by passing it through a vessel containing tow and caustic soda. Equipped with it, Mr. Sept. H. Hedley travelled about 400 yards in the gas, after the explosion at Seaham Colliery, passing over two or three heavy falls, and along a roadway much of which was only 4 feet in height, but no heavier work than exploring was done.

In 1881 the Northumberland Steam Coal Trade appointed a small committee to discuss the advisability of having an apparatus kept in a depôt, ready to be sent to any place at a moment's notice on receipt of a telegram, but nothing further was done at that time.

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[1] Described in *Trans. North of England Mining Inst.*, vol. xxxi.

The Royal Commission on Accidents in Mines (1880–86) considered the use of breathing appliances, and recommended that "arrangements should be made for the establishment of centres in mining districts, where additional appliances for succour and relief, and also special appliances for exploring purposes, should be maintained in an efficient condition, so as to be ready for use at the shortest notice."

The explosion at Altofts Colliery in Yorkshire on October 2, 1886, causing the death of twenty-two men, turned the attention of Sir William Garforth to the subject of rescue work. (See description of this explosion in paper by W. E. Garforth on "The Recovery of Coal Mines after Explosions," *Trans. Inst. of Mining Engineers*, vol. xiv.) In 1899 the Midland Mining Institute appointed a committee to consider the subject, and in their Report they recommended the establishment, at various centres, of rescue stations to serve groups of collieries, the cost being defrayed jointly by the owners of the collieries.

In the following year (1900), the first "rescue station" in Europe, where all the required apparatus is kept in readiness, and having an experimental gallery for testing it and for training men in its use, was erected at Altofts by Mr. Garforth. (See paper by W. E. Garforth, *Trans. Inst. Mining Eng.*, vol. xxii. p. 169.)[1]

This was followed by the erection at Tankersley, in 1904, of a joint rescue station by the Barrow Hæmatite Steel Co. Ltd., Messrs. Newton, Chambers & Co. Ltd., and the Wharncliffe Silkstone Colliery Co. Ltd. (See "A Joint Colliery Rescue Station," by M. H. Habershon, *Trans. Inst. Mining Eng.*, vol. xxviii.)

The First Report (1907) of the Royal Commission on Mines appointed in 1906 was devoted entirely to the use of breathing appliances, and contained some observations which have been verified by subsequent experience.

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[1] As showing the progress which has been made, it is interesting to note what could be done here with the Meyer helmet and pneumatophor in 1901, as stated by Sir William Garforth: "Keeping perfectly quiet a man could remain in the poisonous atmosphere for one hour forty minutes; passing over falls and obstacles he could remain twenty minutes, and when carrying three bricks to build a stopping to keep back a fire he could only remain twelve minutes."

"Apart from actual rescue work, breathing appliances may be of great service in making it possible to deal with underground fires more safely and effectively than would otherwise be the case."

"We do not think that breathing appliances can play more than a subsidiary part in rescue operations after an explosion, but this part may sometimes be of considerable importance."

And they emphasized the importance of selecting suitable men, and of training them thoroughly for the work, and added:—

"The best method of providing for the necessary training and practice is undoubtedly by the establishment of Central Rescue Stations."

The Lancashire coal-owners built a station at Howe Bridge, where a carefully thought-out system of training and working was started in 1908. (See their Rules and Regulations published in Home Office Report for 1909 by Chief Inspector of Mines.)

In 1909 the Northumberland and Durham Coal Owners' Association erected at Elswick, Newcastle-on-Tyne, a central fire and rescue station for their district, a specially designed motor being provided for the rapid transit of the brigade and appliances, and also a motor fire-engine. (See "Fire and Rescue Station of the Durham and Northumberland Collieries Fire and Rescue Brigade," by W. C. Blackett, *Trans. Inst. Mining Eng.*, vol. xli.)

In the same year (1909), stations were erected at Mansfield for the northern portion of Notts and Derbyshire; at Cowdenbeath, N.B., for Fife and Clackmannan; and in South Wales at Aberaman for the Cardiff district, and at Crumlin for the Western Valley Collieries.

A good deal had been done before the first legislative enactment in relation to rescue work was passed on August 3, 1910, namely, "A Mines Accidents (Rescue and Aid) Act," which authorized the Secretary of State to require by

Order such provisions as he may consider to be necessary to be made at all mines in regard to the supply and maintenance of appliances for use in rescue work, and the formation and training of brigades.

At the present time rescue work is governed by the General Regulations, Part IV., issued on July 10, 1913, and by further Regulations issued on May 19, 1914, which, together with a Memorandum on Schemes of Training and Practice, are embodied in "Mines and Quarries Form No. 72," issued by Home Office in February 1915.[1]

As stated in the Report of the Research Committee, 1918, there are at present three ways in which a mine may comply with the regulations relating to rescue training, and these are as follows:—

(1) The mine may be connected with a neighbouring rescue station maintaining a resident brigade;

(2) The mine may be connected with a station at which there is no resident brigade, the brigades being altogether formed of employees of the mines; and

(3) The mine may be unconnected with a rescue station, the whole work of training men and maintaining the necessary apparatus being undertaken at the mine.

In 1916 there were 546 mines attached to fourteen central rescue stations, provided with permanent rescue corps, under the Regulations of May 1914, and 538 mines at which rescue brigades were maintained under the regulations of 1913, the number of brigades being 1219.

The total number of rescue stations in the mining districts throughout the country was forty-six. (See "Report of Chief Inspector of Mines," 1916, Part II.)

"A rescue brigade shall consist of not less than five persons employed at the mine, carefully selected on account of their knowledge of underground work, coolness, and powers of endurance, and certified to be medically fit."

The number of brigades to be organized and maintained at a mine is in proportion to the number of employees. (See "Coal Mines Act," 1911, General Regulations, 1913 Edition, Part IV.)

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[1] See Appendix.

Central Rescue Stations within easy reach of the surrounding collieries are evidently the best arrangement.

"Instructing brigades, practising trained men, and maintaining apparatus are specialized operations which can be conducted more efficiently at a central station than at individual mines" (Mine Rescue Research Committee, 1918).

A colliery explosion nearly always causes heavy falls of stone with displacement of the timber which has been set for the support of the roof, and it is evident that the exploration of a mine under these circumstances by men wearing breathing apparatus, adding about 25 per cent to their weight, is arduous and dangerous work. They need to be men of a thoroughly sound physical constitution, and to be carefully trained for this special work. In the words of Dr. Haldane, who has done so much for the advancement of rescue work, "A man could not dare to play tricks with the apparatus; he must have everything right. . . . The men must be extremely careful; they must be thoroughly trained and thoroughly intelligent, and must know what they were about, what they could do, and what they could not do."

A course of training, as approved by the Secretary of State, is specified in the Regulations (see Appendix).

This training is carried on in experimental galleries, attached to the rescue stations, which are made to afford as nearly as possible the conditions existing in the roadways of a mine after an explosion. Rescue brigades should have also regular training practices underground in a mine.

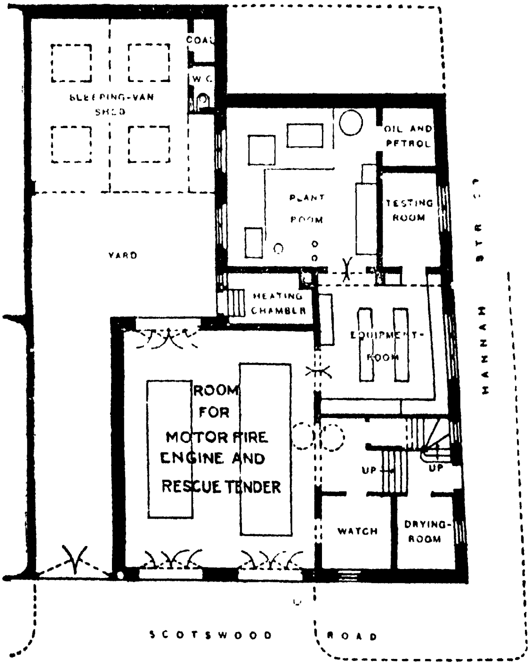
With the Durham and Northumberland brigades this is done once every month.

In the Northern coal-field, the system of Central Rescue Stations, serving a surrounding district of ten miles radius, has been adopted.

Fig. 1 is a ground plan of the Central Rescue Station at Elswick, Newcastle-on-Tyne, and Fig. 2 a second-floor plan.

It is a substantial three-storied brick building. The upper floors contain sleeping and living quarters for the superintendent, the second officer, and for six men, besides a lecture room and the chief officer's office.

Fig. 1.—Ground Plan.

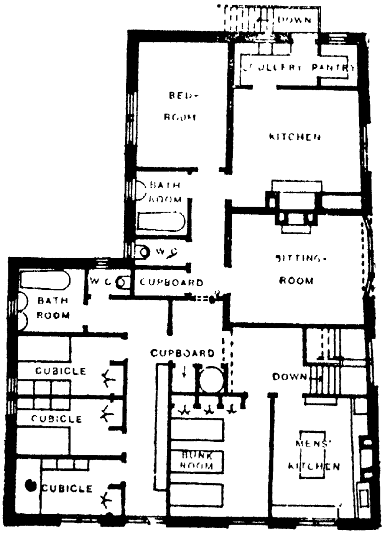


Central Rescue Station, Newcastle-on-Tyne.

In the Watch Room on the ground floor a man is always on duty night and day Here are the telephones, and also switches and call bells, which enable the duty men to call up any man in the building and to control all the lights.

"The equipment of this station includes a 60 horse-power Merryweather motor fire-engine of 500 to 550 gallons per minute capacity; a 25 to 30 horse-power Armstrong-Whitworth tender which carries eight men, portable telephones, hand pumps, eight rescue dresses, and the necessary equipment; a horse-drawn caravan to take out to the collieries for men to sleep in, containing six beds, food for one week, a bath, and a stove; a liquid-air plant, consisting of Dr. Heylandt's liquefier, with three-stage Whitehead compressor, with a capacity for making 20 lb. per hour."

FIG. 2.—SECOND FLOOR PLAN



Scale 20 Feet to 1 Inch.

Central Rescue Station, Newcastle-on-Tyne.

Besides this head station at Elswick there are three similar stations, namely, at Ashington in Northumberland, and at Crook and Houghton-le-Spring in Co. Durham, the four covering the coal-field within radii of ten miles. A full description of the system with much useful information about breathing and other appliances, and a detailed scheme for the organization of a working party when actively engaged in rescue operations, will be found in a handbook by the chief officer, Mr. Frederick P. Mills ("Durham and Northumberland Collieries Fire and Rescue Brigade," published by Andrew Reid & Co. Ltd., Newcastle-on-Tyne).

In connection with the Elswick Station, an old disused Day-drift of a colliery in the neighbourhood is utilized for training the men.

Besides the regular brigadesmen, accommodation is provided for three mining students, managers, or under-managers, and for three miners, who are instructed and trained in rescue work.

PORTABLE BREATHING APPARATUS

There are many difficulties to be faced in designing a breathing apparatus suitable for mine rescue work. A man's breathing varies much according to the muscular exertion he is making, and also according to his body temperature. If the amount of air inspired while at rest is 1, the amount inspired when standing erect is about 1·35, and while walking at the rate of four miles an hour it is about 4·84. (Douglas and Haldane, *Journal of Physiology*, 1912, vol. xlv. p. 235.)

In actual operations underground with a breathing apparatus, it has been found that when walking up an incline having a gradient of 1 in 6¼ at an average speed of 2·15 miles an hour, the average consumption of oxygen was 1·49 litres per minute at 32° F. and 30″ bar.

But up a gradient of 1 in 2 at an average speed of 1·06 miles an hour, the consumption of oxygen was increased to 2·60 litres a minute. (Report of Research Committee, 1918.)

In rescue work, men are called upon to exert themselves strenuously, and a breathing appliance should be capable of supplying the full amount of pure air required under such conditions. We have it on the authority of the Research Committee (see their Report, 1918) that 50 to 60 litres of pure air per minute are ample for the most exacting work the wearer is likely to be called upon to perform with rescue apparatus. It should never fall below 4·5 litres per minute.

The purity of the oxygen is a point of much importance, which is fully dealt with in the First Report of the Research Committee. Analyses of many samples of oxygen taken from different rescue stations showed that most of them were dangerously impure. The Committee recommend that it be made obligatory to analyse the oxygen from every cylinder supplied for use in connection with self-contained apparatus, whether at rescue stations or at individual mines.

"Oxygen containing more than 2 per cent of impurity should never be used in actual work or practice underground with the apparatus . . . and compressed oxygen holding more than 3 per cent of impurity should not be used for self-contained apparatus in any circumstances."

A perfect breathing apparatus ought to adapt itself to the varying requirement of the wearer, both in the supply of air, and also in the removal of the carbon dioxide exhaled.

Quite as important as the oxygen supply is the removal of the carbon dioxide. Several men have lost their lives through failure of the purifier.

Breathing is regulated by the proportion of carbon dioxide present in the reserve air stored up in the air cells of the lungs. This proportion is normally 5·6 per cent. If it is increased by increased muscular exertion or by the presence of carbon dioxide in the air inhaled, the breathing is at once accelerated with the effort to reduce the proportion to the normal. And if the excess of carbon dioxide is not removed, the man rapidly becomes unconscious.

Dr. Haldane has stated that he has seen "complete loss of consciousness from this cause within two minutes, although the air in the breathing bag contained about 50 per cent of oxygen."[1]

The supply of pure oxygen free from carbon dioxide must be amply sufficient, so that there is no fear of the wearer, when his breathing is increased, being obliged to rebreathe part of his expired air before it has been purified from the carbon dioxide. "At all times the lungs should be able to get the volume they require without having to draw on unpurified air."

Evidently, too, a breathing apparatus must be practically air-tight, as any leak outwards quickly reduces the oxygen supply, and any leak inwards may admit poisonous gas which will kill the wearer. Several fatal accidents with breathing apparatus have been caused by leakage.

It is important that the wearer should be able to see clearly not only when walking, but also when stooping or crawling, and also to hear distinctly.

The general design of all the self-contained breathing appliances at present on the market is alike in certain broad features.

They are designed to enable the wearer to breathe and exert himself without any communication with the outer atmosphere for a period of about two hours at a time.

But in actual rescue work with breathing apparatus in its present stage of development, it is a prudent precaution to limit the period of actual work to one hour. This is the rule with the Durham and Northumberland brigades.

The air contained within the apparatus is breathed over and over again, the carbonic acid being absorbed by contact with caustic soda or potash, and fresh supplies of oxygen being added to the air from cylinders containing the gas which form part of the apparatus.

The number and kind of self-contained breathing appliances which were in use in the United Kingdom in 1910 were as follows: Proto, 420; Meco, 222; Draeger, 73;

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[1] See Dr. Haldane on "Self-contained Rescue Apparatus for Use in Irrespirable Atmospheres," Report to the Doncaster Coal Owners' (Gob-fire Research) Committee, *Trans. Inst. Mining Engineers*, vol. xlvii.

Weg, 75;—a total of 790; besides which there were 1199 smoke-helmets in use. (Chief Inspector of Mines Report for 1916, Part II.)

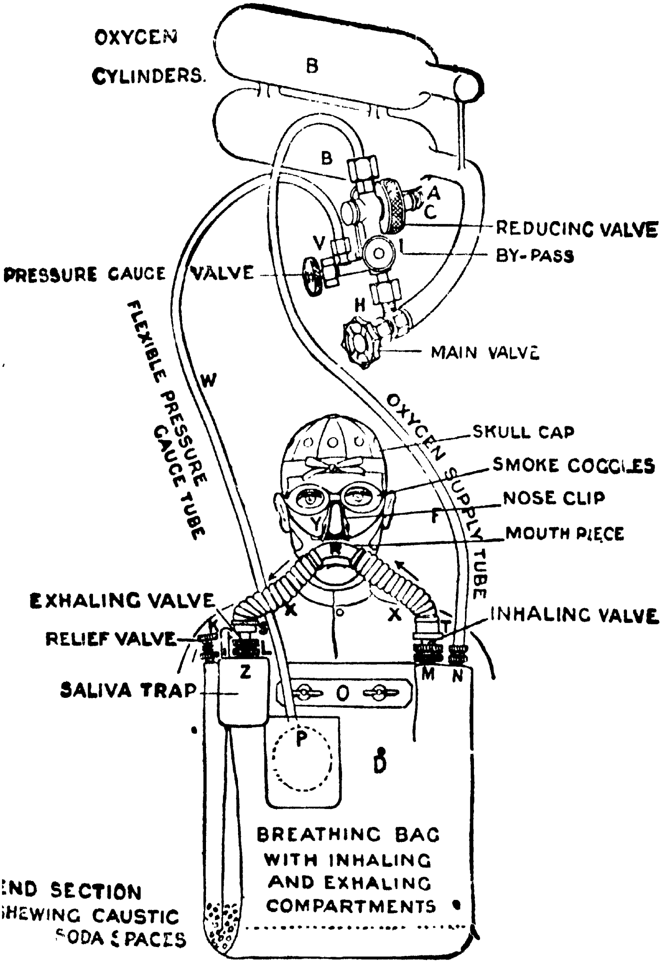
The Chief Inspector's report does not give the number of "Aerophors" in use, but the writer is informed by the Chief Officer of the Durham and Northumberland Rescue Brigades that they had sixty of them in use in 1916, and there were others in use at other rescue stations.

The construction of the Proto apparatus is apparent in the accompanying diagrammatic view and description as supplied by the makers.

A particular feature of this apparatus as compared with others is that the purifying material—the caustic soda—is carried in the breathing bag and not in a separate box or case. This simplifies the apparatus, and has an additional advantage in allowing the sticks of caustic soda to be shaken up, thus rubbing off the outer carbonated scale and making the purifying process more efficient.

In his tests of this apparatus, Dr. Haldane found that the sticks of caustic soda soon became coated with carbonate and bicarbonate of soda. With an oxygen supply of 2·1 litres per minute, during a period of 17½ minutes of active exertion, the percentage of carbon dioxide present in the inhaling tube increased from 0·35 per cent to 5·0 per cent. This caused excessive distress and panting, though there was 50 per cent of oxygen in the air inhaled. By shaking up the bag every few minutes, marked relief to the breathing was experienced. A further improvement has been made by using for the purifying material small lumps or nuts of coke breeze coated with caustic soda. In this form the caustic soda does not become soft and spongy, which it tended to do as used previously. Also the coke breeze absorbs the moisture from the breath, and the saliva trap is not required. More recently the caustic soda has been produced in the shape of small round balls or pellets, which are likely to be more effective than the sticks.

In recent forms of the Proto apparatus the reducing valve is made so that the supply of oxygen can be regulated by the wearer at his option by turning a thumb-screw. Thus he can adapt the supply of oxygen to his varying



The Proto Breathing Apparatus.

requirements from time to time, and there is economy in the use of it. But it should be noted that the Research

Committee state that in practical work the supply of oxygen should never on any account be reduced below 2 litres per minute.

In the use of the Proto apparatus by the Durham and Northumberland brigades the oxygen supply is never set below 2·1 litres per minute, this quantity being fixed as the maximum available from the supply in the cylinders. This is tested every month and a record entered.

Two cylinders containing the oxygen are carried low down on the back of the wearer.

Recently a marked reduction has been made in the weight of these cylinders by the employment of an improved metal in their construction. This metal is a treated steel $\frac{1}{16}$ in. thick tested to 250 atmospheres without having any permanent stretch. These new cylinders are made 3 in. diameter and 32 in. long and hold 17 cubic ft. of oxygen at 150 atmospheres. This is half their bursting pressure, which is about 300 atmospheres. When dropped a height of 30 ft., they are found to bounce. They weigh about 6 to 7 lb., and as the other "Proto" cylinders weigh approximately 17 lb. the improvement is of much value.

Through a by-pass the bag can be rapidly filled at any time with oxygen—a very valuable provision in case of the reducing valve sticking. There is also a relief valve under the control of the wearer, allowing any excess to be discharged.

The gauge carried in front in a pocket on the breathing bag registers the amount of oxygen left in the cylinders, and is in such a position that the wearer can ascertain this at any time.

The weight of the apparatus when charged is 36 lb. with the old cylinders. It is so arranged about the wearer that his head or shoulders are quite free. This is important, as any part of a breathing apparatus carried on the head or shoulders is liable to be damaged by coming into contact with the roof, and is in such a position that the wearer cannot see the damaged place.

MECO BREATHING APPARATUS

Another point of importance is the necessity of cooling the air to be inhaled when working in a high temperature, as men have to do sometimes in case of underground fires. Very hot air, especially if it contains moisture, causes a painful burning sensation in the throat and air-passages. The breathing bag also becomes uncomfortably hot. "An apparatus should be regarded as unsatisfactory if the wet bulb temperature of the inspired air exceeds 105° F. under the temperature conditions commonly met with in the mine" (Report of Research Committee, 1915). This difficulty has been overcome with the Proto apparatus by providing the breathing bag with a third compartment containing sodium sulphate. This salt melts at 90° F., and keeps the temperature at this point until it is all melted.

The bag is worn with the sodium sulphate compartment next the wearer, and this keeps down the temperature next his body, and also cools the air and the caustic soda in the middle or inhalation compartment of the bag.

Tried on a man doing active work for fifty-three minutes in a wet bulb temperature of 84° F., the temperature of the material in each compartment of the bag at the end of this period was: Front compartment, 154° F.; middle, 118° F.; back, 90° F. (See Rescue Apparatus and Smoke Helmets, Second Report by Dr. J. S. Haldane, *Trans. Inst. Mining Engineers*, vol. xlviii.)

In the Meco apparatus (see Plates VIII. IX.) the supply of oxygen and the circulation of the air are maintained, not by the lung power of the wearer, but by an injector which forms part of the apparatus. Before reaching the injector the oxygen from the cylinders is passed through a reducing valve, which lowers the pressure to about 5 atmospheres, or 75 lb. per square inch, and controls the flow to a uniform quantity of about 2 litres of oxygen per minute. This quantity can be increased or reduced by turning a regulating screw; but this cannot be done by the wearer after he has put on the apparatus.

At the injector the oxygen is mixed with the purified exhaled air from the regenerator, and the mixture is forced on into the mouthpiece or the helmet. The apparatus is adapted for either a helmet, or a mouthpiece, or a half-mask.

The breathing bag has two compartments, one for inhalation and the other for exhalation. The inhalation tube is carried right through the inhalation compartment to the mouthpiece, but the tube has an opening into the bag, which thus serves as a reservoir for the purified air. Similarly, the exhalation tube passes through the exhalation bag and has an opening into it, so that the bags supply a large additional breathing capacity in case of an unusual demand. See Plates VIII. IX. X.

In the metal regenerator which is carried on the back above the oxygen cylinders, the exhaled air is coursed to and fro over wire-gauze trays holding the caustic soda, and giving as large a surface as possible for the absorption of the carbonic acid gas.

In this arrangement there are no valves in the breathing tubes. The weight of the apparatus when charged is 38 lb.

There have been many accidents with breathing appliances, which, on investigation, have been found to be due to leaks in the apparatus, tiny holes admitting the poisonous gas from the outside.

In the injector type there is liable to be a negative pressure—a pressure below atmospheric pressure—on the suction side of the injector. Professor Sir John Cadman of Birmingham University has made a special investigation into this matter, and has shown by experiment that this negative pressure does exist. (See Mine Rescue Appliances, Professor John Cadman, *Trans. Inst. Mining Engineers*, 1912–13, vol. xliv. p. 463.)

It measured in one instance, – 3·3 inches of water-gauge near the back of the injector. This, of course, increases the danger of the tiniest leak in the apparatus. By a small alteration to their apparatus—by changing the position of the excess relief valve, and introducing another

MECO BREATHING APPARATUS

small breathing bag in the pipe leading from the regenerator to the injector—the Meco Company has surmounted this difficulty. This additional breathing bag also acts as an indicator to show whether there is any leak in the apparatus when in use, because it remains inflated so long as there is no leak.

It is fully described with illustrations in a paper by Mr. Harold C. Jenkins. (See "Some Recent Experiments with Internal Pressures in Pneumatophors," *Trans. Inst. Mining Engineers*, 1912–13, vol. xlv. p. 230.)

The Research Committee in their Report, 1918, condemn the injector type of breathing appliance on the ground that "unpurified air is used to make up the indrawn volume when the lungs' demand exceeds the injector's supply."

"There is no gainsaying the fact that the injector as an adjunct to breathing apparatus is a grave source of danger."

"We recommend that it be abolished in all future rescue apparatus, and that existing apparatus be altered as soon as practicable, to eliminate the injector."

The Weg apparatus (see Plate I.) was designed by Sir William E. Garforth, and is named after the initials of his name. In comparison with other forms, its special feature is that the supply of oxygen is automatically controlled by the lungs. A delicately adjusted valve regulates the pressure, so as to correspond with the breathing of the wearer. In the words of the inventor: "By means of this arrangement, the oxygen, at a pressure of 1800 lb. per square inch, is governed by the action of the lungs, in the same way that the supply of steam is regulated by the governor balls actuating the throttle valve of an engine."

The two cylinders containing the oxygen are curved in shape, and are carried at the waist one on each side, making a comfortable balance.

The breathing bag and a purifier above it are carried on the back.

The weight of the apparatus when charged is 40 lb.

The Weg apparatus was adopted at the Cowdenbeath Rescue Station of the Fife and Clackmannan Coal Owners' Association, when first opened in 1910, and has been in use there ever since.

During this long experience with it, important improvements have been made by Captain Stevenson, who is in charge of the station, and by Mr. Joseph Parker, the Principal of the Fife Mining School at Cowdenbeath. (See "An Account of Some Attempts to improve Rescue Apparatus," by J. Parker, *Proceedings National Association of Colliery Managers*, 1915, vol. xii. and subsequent discussions.)

A supply of oxygen adapting itself automatically to the breathing is a most desirable feature in a breathing apparatus, but experience with the Weg has shown that it is a very difficult object to secure in practice.

There is, too, the serious drawback that if the wearer faints or becomes unconscious, his supply of oxygen is stopped.

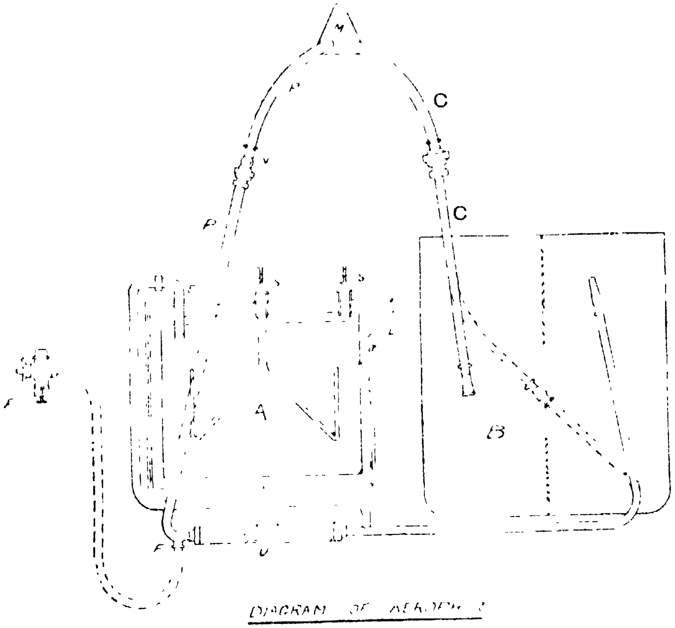
An adjustment of the automatic valve, giving a supply of oxygen suitable for one person may be quite unsuitable for another. A rise or fall in the atmospheric pressure affects the action of the valve, and consequently the action of the lungs in opening the valve. The fall of pressure of the gas as the supply in the cylinder becomes exhausted, also alters the force required to be exerted by the lungs of the wearer in order to open the valve.

These were some of the considerations which led to the design of a combined reducing valve and oxygen-supply adjuster, which is described by Mr. Parker in his paper.

This combination passes a definite minimum supply of oxygen under all conditions and can be increased at will in small increments between the limits of 1 to 3 litres per minute. These limits cover normal requirements. Above 3 litres small increments are considered unnecessary.

It is now generally recognized that a mouthpiece is better than a helmet or half-mask. The Research Committee recommend, with regard to existing types of self-contained breathing appliances, that the helmet and face mask should be abolished. It requires practice to get accustomed to a mouthpiece, as all the breathing has to be done through the mouth, and a nose-clip must be worn, and there is too a difficulty in speaking.

But, after many severe tests, Dr. Haldane has stated



The Aerophor used by the Durham and Northumberland Rescue Brigades.

that "With a good and properly secured mouthpiece a tight joint is obtained, and men soon accustom themselves to a mouthpiece, and learn to make themselves understood through it."

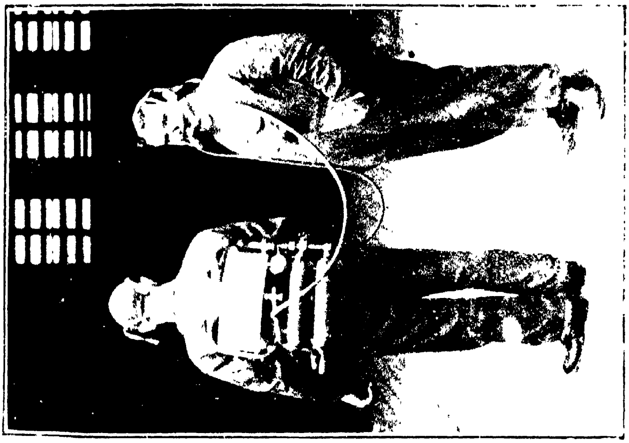
The Aerophor differs from all the other types of breathing apparatus in utilizing liquid air instead of compressed oxygen.

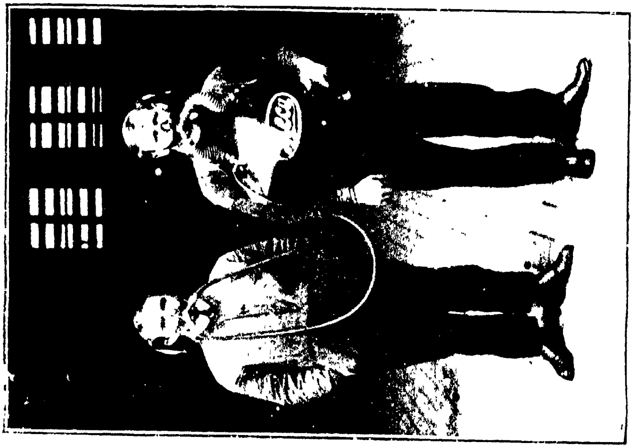
Air liquefies at a temperature of about −175° C. (or −312° F.). As a liquid it occupies a space about $\frac{1}{800}$th part of what it occupies as a gas, that is, one cubic foot of liquid air is equivalent to about 800 cubic feet of air.

In the process of liquefaction the air is first compressed to a pressure of about 3000 lb. per square inch, then cooled by circulating through tubes, and then suddenly expanded in the liquefier, which lowers its temperature to the point at which it becomes a liquid.

As used at the Newcastle station and described by Mr. Frederick P. Mills, the chief officer, the Aerophor consists of a case A, made of cupro-nickel, so shaped as to fit into the small of the back (see preceding page). This case is filled with asbestos wool lightly packed round drains made of fine wire gauze. Liquid air is poured into this pack through the valves S, S, and distributes itself by means of the drains. The asbestos wool absorbs the liquid air, as a sponge does water. The charge is 8½ lb. and lasts on an average 2½ hours. The liquid air, which contains 60 per cent of oxygen, evaporates and passes through the pipe E, becoming warmed in its passage. Thence it goes into the breathing bag or storage reservoir B, and along a tube C, through a non-return valve, to the half-mask M.

The expired air passes by the tube P, through a similar valve, to a moisture trap and purifier U, containing the caustic soda for absorbing the CO_2, after which it joins the fresh air supply to the breathing bag. At V is fitted an exhaust valve which is set to blow off at 6 inches water gauge, or a pressure of 31·2 per square foot, and thus acts as a safety valve to relieve any excessive pressure. The pack is sewn on to a light canvas waistcoat with which the breathing bag is incorporated. Pockets are provided on the right and left side of the waistcoat; in one the alarm watch is carried, and chalk in the other. The watch is set to sound an alarm when one-half of the time that the supply of oxygen will last is reached. The weight of the apparatus fully charged is about 36 lb., which is reduced to 27½ lb. after two hours' use.





A drawback to the Aerophor hitherto has been its large consumption of oxygen, but this is in course of being rectified, as a result of the war. The Air Force has been developing and improving liquid air apparatus for use in aeroplanes at high altitudes. The reduction in the weight of the oxygen cylinders, already mentioned, is due also to their efforts. The Germans, too, with their usual efficiency in such matters, have been making great progress with liquid air appliances for producing oxygen as an antidote to poisonous gas in the trenches. The Aerophor is likely to be much improved before long.

An oxygen-reviving apparatus is one of the appliances which must, under the legal regulations, be provided and maintained at every mine.

Some of these appliances are fitted with small pumps which force the air into the lungs, and on the reverse stroke draw it out again. It has been shown, however, that this mechanical suction has an injurious effect on the lungs and air passages, and that such appliances may do serious harm to the patient. The safest treatment is to combine the simple supply of oxygen with artificial respiration by the Schaefer method, as shown in Plate XI., supplied by Messrs. Siebe, Gorman & Co. Ltd.

The treatment of persons who have been affected by breathing poisonous gases has been well summarized as follows:—

Make the patient lie down. Keep him warm. See that he has plenty of fresh air. If he is blue in the face, (1) administer oxygen; (2) if he has not been sick, give him a drink of 1 oz. of salt in 10 oz. of lukewarm water, and repeat the dose until he is sick; (3) meantime send for a doctor.[1]

Smoke or Bellows Helmets have been found useful in dealing with underground fires, where the suffocating gases do not extend very far. Fresh air is forced into the helmet through a flexible pipe by a bellows or pump. Sixty or seventy yards are about the limit to the length of pipe.

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[1] Useful information on oxygen reviving apparatus will be found in a paper by Mr. F. P. Mills, F.S.I., "Resuscitation from Mine Gases," *National Association of Colliery Managers*, January 1917, vol. xiv.

In comparison with self-contained breathing apparatus the smoke-helmet has the advantage that more air and drier air can be supplied. In some trials made by Dr. Haldane a delivery of air of 200 litres per minute was maintained.

"With good impervious clothing, and a proper supply of the very dry air furnished by the compressed-air mains of a mine, there is no doubt that a man with a smoke-helmet could work in atmospheres where ordinary self-contained apparatus would be useless, and where work without apparatus would be equally out of the question. . . ."

"With the smoke-helmet, if the coat is properly buttoned up over the leather flap of the helmet, the air passes down over the body and exercises a powerful cooling effect."[1]

At the Doncaster Rescue Station a breathing apparatus in its simplest form is in use for penetrating short distances into an irrespirable atmosphere. This consists of about 50 yards of flexible tube 1 inch in diameter with mouthpiece and nose-clip and breathing valves attached to one end of the tube. A man can slip this on very quickly, and with it go as far as the length of tube will allow him, into a poisonous atmosphere, drawing his breath through the tube from its open end which is left in fresh air.

The Newcastle Brigade have in use a smoke-helmet of special design (see Plate VII). It includes a telephone, so arranged that whilst wearing the helmet a man can communicate with those outside the danger zone. The telephone wire passes through the air-pipe, which is 1 inch in diameter and made of wire-embedded rubber hose so strong that it cannot be crushed by a man standing on it.

Several breathing appliances of a lighter and simpler type, such as the "Drager Self-Rescue" and the "Huskisson

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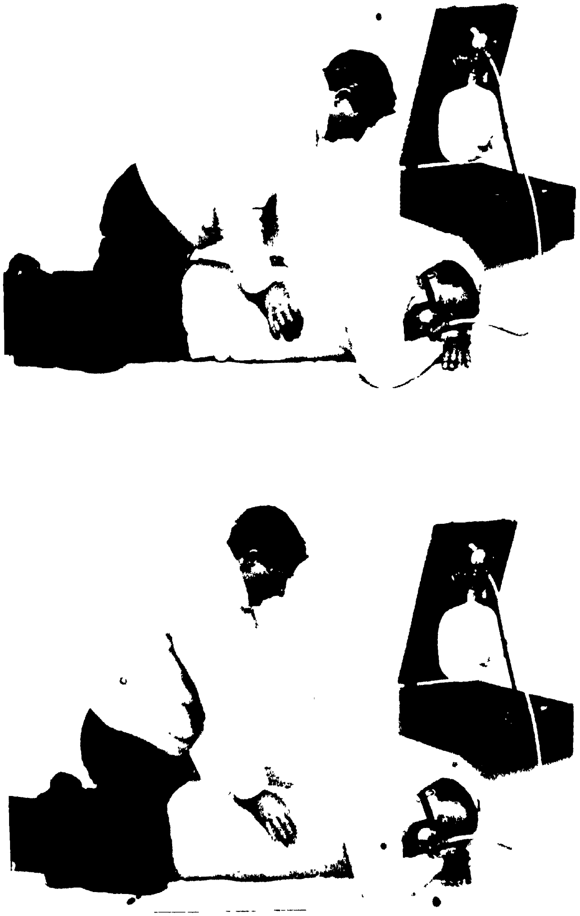
[1] Dr. Haldane.



OXYGEN REVIVING APPARATUS COMBINED WITH ARTIFICIAL RESPIRATION BY THE SCHAEFER METHOD

Emergency Type" (see *Trans. Inst. Mining Engineers*, vol. xlvii.), have been designed. They are intended to serve for a short period in cases of emergency, and may be kept in-bye in the underground workings so as to be available at short notice.

To answer a similar purpose, a simple attachment to be used with the Meco apparatus has been designed by Mr. Michael McCormick, the instructor at the Edinburgh Rescue Station. (See *Trans. Inst. Mining Engineers*, vol. xlix.) This is shown in Plate VIII.

The object of the attachment is to enable a man who may be found alive to be brought out through an irrespirable atmosphere. It would be useful also in the event of one member of a brigade breaking down. It weighs about 2½ lb., and is intended to be carried by the rescuers.

INSTANCES OF SUCCESSFUL USE OF BREATHING APPARATUS

The value of self-contained portable breathing apparatus was fully proved during the war in mining operations on the Western Front, as the following extract shows (taken from a paper by Major H. Standish Ball, "The Work of the Miner on the Western Front," *Inst. of Mining and Metallurgy*, 1919):—

"A large amount of valuable work was done by the Mine Rescue Squads, many lives being saved and important mining work carried out by men working in irrespirable atmospheres while wearing mine rescue apparatus.

"The following is an account of the biggest mining operation carried out under such conditions: In a certain important sector of the front where mining operations had been commenced first by the enemy, it was discovered that one of his galleries had approached to a position greatly endangering the safety of our lines. Unfortunately, through the explosion of an enemy camouflet, our galleries were flooded with gas and it was found impossible to work underground to insert a charge, the atmosphere being so vitiated that canaries immediately expired on exposure to the mine air at the top of the vertical shaft. It was therefore decided to charge up with the aid of mine rescue men, two officers and seventeen other ranks being selected for the purpose. At a depth of 80 ft., and at a position 100 ft. from the shaft, a charge of 5000 lb. was successfully inserted with 65 ft. of solid tamping, in spite of the fact that the last 40 ft. of the gallery only measured 3½ ft. by 2¼ ft., and was badly damaged by a previous explosion. Each man spent ten hours in the poisonous atmosphere, working in short shifts, the whole enterprise taking forty-three hours. It is pleasing to record that the mine was laid and fired in time to save the mining situation, and no casualty was suffered during the whole proceeding, this being a tribute in itself to the efficient supervision and training of the men."

There have been unfortunately several instances both in this country and abroad of men losing their lives when using breathing apparatus, but there are also instances where its value has been proved in saving life, in recovering mines after an explosion, and in dealing with underground fires, under circumstances which would have endangered human lives had no appliances been available. The first recorded case of a life saved by the use of portable breathing appliances in coal mining in this country occurred on January 28, 1913, at Lodge Mill Colliery, a small colliery about four miles from Huddersfield. Four men employed during the night-shift in removing rails in a disused part of the workings were overcome by gas. Numerous and continued efforts were made to reach them and bring them out, but the suffocating nature of the atmosphere rendered this impossible.

A call for help was sent to the Altofts Rescue Station, and six trained men of the Altofts Rescue Brigade left at once. Owing, however, to the break-down of a motor, it was not till the afternoon, some nine hours after the men had been overcome by the gas, that three members of the Rescue Brigade arrived at the colliery.

The place where the men were lying was about a mile from the shaft in a thin seam, and the roads on an average were not more than 3 feet high. The rescuers, wearing the Weg apparatus but carrying their headpieces, were run in-bye lying flat on small trams until they reached a point about 80 yards from the place. Then, donning the full equipment and carrying electric lamps, they went forward and found the men lying close to the face of a road little more than 2 feet high. They succeeded in bringing out to the fresh air all the four men, using small trams for this purpose and making four journeys through the suffocating gas. Two of the four were still breathing, but in a very critical state. One recovered completely in a few days, but the other died in the Huddersfield Infirmary. The other two, who were older men, were dead when found. There can be little doubt that if rescue appliances had been available at the first, the lives of all four men would have been saved. (See paper by W. D Lloyd, "An Account of the Use of Rescue Apparatus at Lodge Mill Colliery, Huddersfield," *Trans. Inst. Mining Engineers*, vol. xlvi.)

The value of rescue apparatus has been proved also in the recovery of a mine after an explosion due to a gob-fire. (See *Trans. Inst. Mining Engineers*, vol. xlv., "The Re-opening of Norton Colliery with Self-contained Breathing Apparatus after an Explosion," by J. R. L. Allott.)

At Norton Colliery in North Staffordshire an explosion occurred on February 24, 1912, on a Saturday afternoon when fortunately no one was in the pit, but some men were working in the shaft. Only one man was killed, but it was a great explosion causing much damage to the mine. Within three hours after the explosion had occurred, six trained men of the local rescue brigade wearing apparatus of the Proto-Fleuss type, descended one of the three shafts and made an examination—lasting for twenty-five minutes A second team descended soon afterwards, and their reports led to the decision to stop the fan and seal up all the pits and fan évasée, as another explosion was feared, owing to fire in the workings. During the next few days samples of air from the sealed shafts were taken daily and analysed, and tested for carbon monoxide by the blood test and by the effect on a mouse, and on March 2 one of the three shafts was re-opened, and a party wearing the rescue apparatus descended the shaft 386 yards in depth, in the cage, having with them mice, a canary, and safety (oil) and electric lamps. All the safety (oil) lamps were extinguished, but the mice and the canary were not affected. Analyses of the air had shown the presence of firedamp in the proportion of about 5 to 8 per cent, and traces of carbon monoxide.

The investigation led to the conclusion that the explosion had originated in some "dip" workings in the Cockshead seam, and that an old gob-fire was the most probable cause. The seams lie at an inclination of 13 degrees. The workings in question were reached by two "dip" headings with levels branching from them. It was decided therefore to build stoppings at the top of these "dip" headings in order to prevent the circulation of air in the district where the fire was situated. This work was accomplished by March 9. The roadway was large, the seam being 8 feet thick, and the stoppings were made of wooden blocks. Strong doors 2½ feet square were built in the middle of them, and a 2-inch pipe with a valve, so that samples of air could be taken for analysis. The pressure of the accumulated gas pent up behind the stoppings was so great that strong sprags had to be set against them. This pressure reached as high as 8·9 inches of water gauge, or 46 lb. per square foot.

Analyses of the air from behind the stoppings showed at times a proportion of firedamp as high as 74·5 per cent.

These Cockshead "dips" remained sealed till April 2. The work of recovering them was then commenced with a view to reaching the gob-fire district, and sealing it off by building stoppings near to it. In order to accomplish this without admitting fresh air, which of course would aggravate the fire, and probably cause further explosions, it was decided, after much discussion, that the work could best be carried out by the rescue brigades. Three teams of five men each were chosen. They were men of ordinary physique and build, the lightest weighing 9 st. 8 lb., and the heaviest 15 st. 10 lb., and their ages varied from 23 to 43. They had gone through a course of training at the Stoke centre, and several of them had had a little actual experience at neighbouring collieries. The apparatus used was the Proto-Fleuss-Davis pattern made by Messrs. Siebe, Gorman & Co. Limited (see on page 225). An oxygen trunk was always kept within a few yards of the point at which the men were working.

In recovering the "dips," which were heavily fallen in places, they worked one and a half hour at a time inside the stoppings, and then for one and a half hour they remained in attendance outside the stoppings, with their apparatus on, but uncoupled, ready for any emergency. During their daily shift each team did three hours' actual work inside the stoppings in one and a half hour turns, and three hours in attendance outside the stoppings.

Their work of recovery, consisting of clearing falls, setting timber, laying way, replacing doors and air crossings and building new stoppings, occupied about four months, till near the end of July. They worked, wearing the apparatus, for 120 days; and during this period actually lived on their oxygen for 360 hours.

Early in June the men were medically examined by Dr. J. S. Haldane, who reported that though the strain of the work was evidently considerable, he "could find no indication of any physical deterioration, except what a short holiday would very rapidly make up for."

The successful accomplishment of this arduous work in an atmosphere which was absolutely irrespirable, being practically devoid of oxygen, and in a temperature which reached 75° F., reflects the greatest credit on them, and also on Mr. Allott and his assistants, to whose care and attention to detail the success was mainly due.

There are other instances on record where breathing apparatus has proved most useful in dealing with underground fires, but this Norton case is the longest and severest practical test of its value which has yet been recorded.

AMBULANCE WORK

Rescue work with its comparative novelty has somewhat cast into the shade the no less important Ambulance Work or the rendering of "First Aid" to the injured, which indeed to a large extent forms the basis of rescue work. One of the Regulations governing rescue work is that the majority of the members of a rescue brigade shall be trained in "First Aid."

When one thinks of the large number of minor accidents which occur in mines, and of the consequent suffering and injury, the value of "First Aid" is apparent. It is truly stated in the Report of the last Royal Commission on Mines (1909) that a knowledge of ambulance work or First Aid is probably of greater value in mining than in any other occupation.

Some forty years ago, in 1877, the St. John Ambulance Association was established with the object of spreading among people of all classes of society a knowledge of how to give immediate help to the injured, how to stop bleeding, to set broken bones, to bandage wounds, to carry an injured man, and so on, until the services of a doctor can be secured.

Lectures on "First Aid" by medical men, giving instruction about the structure and functions of the human body, and classes for practice in tieing bandages, setting splints, etc., have been a common feature in colliery towns and villages for forty years past.

Within recent years the movement has been consolidated by the formation of St. John Ambulance Brigades, the members of which maintain and improve their knowledge and training by regular drills and practices, and undergo an annual inspection to test their proficiency.

This ensures a well-trained body of men ready and able to give valuable help in the presence of accidents or of sudden illness.

The Coal Mines Regulation Act, 1887, contained a General Rule, then new, that "Where persons are employed underground, ambulances or stretchers, with splints and bandages, shall be kept at the mine ready for immediate use in case of accident."

A reference to the present Ambulance Regulations (dated July 10, 1913), a copy of which is appended, shows that considerable progress has been made during the twenty-six years. Every candidate for the colliery manager's certificate of competency must now produce a First Aid certificate of the St. John Ambulance or the St. Andrew's Ambulance Association, or other society or body approved by the Secretary of State. And according to the Ambulance Regulations now in force, there must be, if possible, at least one man trained in First Aid and holding a certificate (as above mentioned) in every district of a mine where twenty persons or more are being employed.

Much suffering and permanent injury may be prevented or at least alieviated, and life itself may sometimes be preserved, by First Aid rendered promptly and efficiently.

CHAPTER XX

MINERS' HOUSES

AN adequate supply of suitable houses in healthy surroundings such as will help—and not hinder—the occupiers to live in decency and comfort and to bring up children having sound minds in sound bodies, is an achievement greatly to be desired in the best interests of the whole community. It is one of the weightiest elements of the labour problem, and, as prominent statesmen have declared, it lies at the root of all social reform. But unfortunately it is as yet an ideal which is very far from having been attained in this, or probably in any other great industrial country.

The serious shortage of small dwelling-houses at rents of about 4s. to 10s. a week, and the grievous defects of many of those that exist, are crying evils which have been increasingly pressed upon public attention during recent years.

It was stated by the Prime Minister in December 1918, that returns from the Local Authorities indicated that in England and Wales alone there was a shortage of at least 400,000 houses.

The demand for houses is most urgent in many districts, but the supply, far from increasing to meet the demand, has been falling off.

While our population and the demand for houses have been steadily growing, building enterprise has been paralysed.

In 1901, with a population (England and Wales) of 32,500,000, the number of dwelling-houses in course of construction was 61,909, but in 1911 it was only 38,178, though the population had grown to 36,100,000. (See "Statesman's Year Book," 1917.)

At the beginning of the century, in 1901, more than a million men were engaged in the building industry (England and Wales), a larger number at that time than in any other industry except agriculture; but in 1911, when a fresh census was taken, the number had fallen by 96,737 men, though the population had increased during the same period by 3,600,000.[1]

In the past it has been the speculative builder, assisted by private enterprise, who has met the demand.

As shown in the valuable Report of the Land Inquiry Committee (1912), chairman, A. H. Dyke Ackland (which should be studied by every one interested in the housing question), this has still been the case, even since Parliament has given special powers for the provision of houses to Local Authorities and Public Utility Societies.

Taking the ten years 1903 13, the Committee estimated that about 99 per cent of the working-class houses were supplied by private enterprise.

On every hand we hear and read of the great demand for houses, and yet the source from which they have been supplied in the past is drying up.

It is a national calamity that the building industry, or any other industry that does valuable service to the whole community, should be paralysed.

What are the causes?

The Finance Act (1909-10) gets much of the blame. Undoubtedly it has had a most depressing effect on building enterprise. It has created a sense of insecurity and of uncertainty as to the future, and has destroyed credit. Builders cannot borrow money on mortgage as they did, and the Increment Value Duty imposed by this Act upon any transfer of land has had the effect of stopping builders from buying land for building purposes. It has been to the building industry what the last straw was to the camel's back, but the mischief had begun before this Finance Act came into force.

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[1] The author wishes to acknowledge his indebtedness to a useful little book by Watkin Williams, called "Wigwam: A Key to Social Reform." Cardiff: The Educational Publishing Co. Ltd.

The two chief causes seem to be (see Report of Land Inquiry Committee, 1912) the ever-growing burden of local rates, which falls with special severity on small house property, and the increased cost of building.

House property is no longer the attractive investment which it once was. There are now a variety of other investments available to the small investor which pay better.

The amount of expenditure which has to be met out of local rates has been growing rapidly during the last ten to twenty years.

Under our system the bulk of the rates is levied on buildings, and this constantly increasing tax on buildings necessarily tends to restrict the supply.

Much of this expenditure too is for services such as poor relief and education, which are in the interests of the whole nation, and it does not enhance the value of the property on which the rates are levied.

And as the rateable value is assessed on the rental of the house, the system tends to prevent improvements in houses as this entails not only a higher first cost, but an increase in the yearly rates.

Higher rates lead to higher rents, and these again to a higher rateable value.

Assessment Committees like to keep up rateable values so as to make the rate per £ as low as possible, and the owners of small house property are seldom in a position to dispute the decisions of Assessment Committees.

"If a cottager improves his dwelling, and if he puts a bath into his house, he is taxed the more for it than would be his less clean and tidy neighbour cottager" ("Wigwam," by Watkin Williams).

To show how rates have increased, a few figures may be quoted:—

In 1870 the total rateable value (England and Wales) was £104,870,334, and it had increased to £175,622,758) in 1899. Of these totals, buildings—including houses (other than farmhouses), shops, warehouses, mills, factories, and docks—contributed in 1870 a proportion of 52·6 per cent, and in 1899, 66·3 per cent.

But the rates per £ have risen much faster than the rateable value. During the ten years 1901 to 1911, the assessable value in England and Wales rose from £168,418,759 to £205,314,046, an increase of 21·9 per cent, and the total rates from £42,993,668 to £65,152,299, or 51·5 per cent.[1]

Thus the expenditure which has to be met out of the rates has risen more than twice as fast as the assessable value.

During the same period (1901 to 1911) the average public rate per £ of valuation has increased from 6s. 4d. to 7s. 3d. (= 14½ per cent) in the County Boroughs, and from 5s. 8½d. to 6s. 8d. (= 17 per cent) in the Urban Districts of England and Wales. (See Report of Land Inquiry Committee.)

In some mining districts the rates constitute as much as 37 per cent of the rent of miners' cottages. An instance is given hereinafter where the rates are 2s. a week on cottages rented at 5s. 6d. a week, and 2s. 6d. where the rental is 6s. 6d.

"It is probable that on the average, between one-sixth and one-fifth of the total income of working-class families is spent on rent and rates; the proportion varies inversely with the amount of income. In the case of very poor families the proportion is sometimes more than one-third." (Land Inquiry Committee Report, 1912.)

The increased cost of building is another cause of the dearth of small houses. This increase is threefold: in the cost of materials, of labour, and of money. Most of the smaller houses are built with borrowed money, and higher interest has to be paid for it.

The Land Inquiry Committee put the increase in the cost of building materials during the nine or ten years preceding 1912 at 10 or 12 per cent. As about three-fifths of the cost of working-class houses is for materials, this is an advance of £12 to £15 on a £200 cottage. This was before the war. Now (1919) labour is the largest item in the cost of building houses, wages having increased enormously.

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[1] In 1913-14 the total receipts from Rates (England and Wales) were £71,276,158.

The general result of the increased cost of building and the increased burden of local taxation is that it does not pay to build working-class houses. Work-people cannot pay the rents required to make it a profitable enterprise.

This statement needs to be qualified by the fact that both the local rates and the cost of building vary much in different districts, as also do the wages of work-people.

As regards the cost of land for building sites, and the cost of development, that is, of making roads and footpaths and sewers, some useful figures are given in the Land Inquiry Committee's Report (p. 116).

Land at £500 an acre with twenty houses to the acre is equivalent to 4s. 6d. per week, rent per house. Halve the number of houses per acre, and this rental equivalent will be doubled. The cost of roads and sewers is put at £250 to £300 per acre.

Taking it at £250 and the land at £500, with twenty houses to the acre, the rental equivalent for cost of building sites, of drainage, and of roads, will be 6s. 9d. per house per week.

The cost of development, for building-plots of 100 to 125 square yards, is very commonly between £12 and £20 per plot.

These figures are corroborated by some instances of costs of making roads and sewers in mining villages given farther on.

In connection with the coal-mining industry, the housing difficulty is acute. There is a serious deficiency of houses in many districts, and in the older districts, where the existing houses have been built fifty years ago or more, they are far from satisfying modern requirements.

It is always a difficult matter to alter or to replace existing houses, especially where they may not be wanted much longer, owing to coal seams being worked out; and in the case of new collieries, bringing within a few years a population of thousands of people, into districts hitherto unpopulated and void of houses, the provision of an adequate supply is not an easy undertaking.[1]

Colliery shafts are sunk in all sorts of localities, in rural areas and in urban areas, in narrow valleys bordered by steep hills, where there are few or no sites suitable for building, and on wide flat plains lying very little above sea-level, where drainage and the disposal of sewage are difficult and costly problems.

That colliery shafts are often sunk in out-of-the-way places where there are no houses, makes it necessary, in such cases, for the colliery owners to provide houses for their work-people, at any rate at first, till other agencies get to work.

In some districts, as in Durham and Northumberland, the system of "free" houses prevails, under which a house, free of rent, is recognized as part of the miner's wage. This system arose in the two northern counties when the "binding" system was in vogue, under which miners were "bound" to work for a year for the same employer, but this was abolished in 1844.

Now it is, and for a good many years past it has been, the recognized custom to pay a rent allowance to miners who are not living in houses belonging to the colliery owners. This rent allowance amounts at present in Co. Durham to about 2s. 9d. a week, and naturally many colliery companies prefer to pay the rent allowance rather than face the large capital expenditure required for building houses.

As an instance of the expenditure incurred, at the annual shareholders meeting on November 22, 1918, of the Horden Collieries Limited, which has developed large new collieries in South-East Durham, the chairman, Sir Hugh Bell, called attention to the interesting fact that of the £1,300,000 capital employed in the company, they had expended £500,000 on houses for the men.

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[1] It may be useful to mention that in the Report of the Royal Commission on the Housing of the Industrial Population of Scotland (published in October 1917) it is stated that the cost of adding a scullery and boiler to each house, and a water-closet for every two houses, in rows of old miners' houses amounted a year or two before the war to about £25 a house.

Under modern conditions the "free" house system is not to be recommended, but there are many difficulties in changing a long-established custom of this kind.

Colliery owners have some special advantages in building houses for their work-people. They can build on a large scale, and thus more economically. The houses are usually built by contract, and large building contractors can undertake the erection of some hundreds of houses at a lower rate per house than would be required for a few. Ironmongery, grates, and wood-work, etc., can be standardized, and materials bought at wholesale prices. But authorities differ as to the saving that can be thus effected.

"If forty or more houses were erected at one time, there may be a reduction in cost of about 2 per cent. It is doubtful, however, whether any but large contractors will be able to make this reduction, as it is a question of using available building plant and the application of good business methods to the work in the course of erection" (John Wilson, Special Report, 1917, Royal Commission on Housing in Scotland).

On the staff of a large colliery there are usually one or more officials who have had some experience in the design and the construction of small houses.

A clerk of the works can be employed to see that the work is properly done, and there are masons and joiners regularly employed who can attend to the repair and maintenance of the houses when built.

Rents can be deducted from wages at the colliery office, and though some people seem to think that this is a symptom of serfdom, it really saves trouble to both parties, and is quite agreeable—at any rate in many instances—to the tenants.

Again, colliery owners can as a rule obtain land for building on easy terms. In rural districts a rent of double the agricultural value of the land per acre for a term of forty years or more is not an unusual arrangement, and this amounts often to only £2 or £3 an acre.

One of the first requisites for any collection of dwelling-houses is an ample supply of water, both for sanitary and for domestic purposes, and many colliery shafts can supply large quantities of water.

IMPROVED HOUSES

A comparison of miners' houses and miners' villages built recently with those built forty or fifty years ago or more shows that great advance has been made in the type of house provided, and in the general lay-out of colliery villages. If the best evidence of a people's progress may be found in the houses in which they live, there is ample evidence here of the progress of the miners.

Forty to fifty years ago the best miners' cottages consisted, in general, of three rooms, namely, a kitchen, a room above, and a small room behind under a sloping roof.

Miners' houses built at a colliery in Northumberland in 1875, which at that time were considered to be excellent houses, and a great improvement on those built previously, provided on the ground-floor a kitchen living-room 18 ft. by 15 ft., a kitchen scullery 13 ft. by 9 ft. with a sloping roof, and a pantry 3 ft. by 7 ft. 6 in. On the first floor a second small bedroom 4 ft. 6 in. by 12 ft. was taken out of the available area by a light partition, leaving one fair-sized room.

The ground area occupied by the house was 20 ft. front by 28 ft. gable.

They were built of stone, quarried in the neighbourhood, the outside walls being 18 in. thick, and inside 14 in. The roofs were slated.

Privies and ashpits were provided at a little distance from the house. The cost of building was about £120 a house.

These houses were a vast improvement on those built early last century. The writer can testify from some experience, having lived for some time in one of the old cottages close to the pit, built about 1802, in the old West Moor village of Killingworth Colliery, Northumberland (famous for its associations with George Stephenson, who designed his first locomotives when employed there as colliery engine-wright). The rooms were small and low, and the windows as a rule would not open. Sanitary appliances were non-existent. The only sewers were open, running past the cottages near the doors, so that they had to be crossed by those going in and out. No miners, however large their families, had more than two rooms, and newly married men had to be content with one small room.

Yet many of them lived to a hale old age, working regularly down the pit. In 1874 there were upwards of thirty sexagenarians working at West Moor, and several of seventy years and more were still at work.

This strength and longevity were due perhaps to the fact that they had no inducement to stay indoors, and from their earliest years they spent most of their time, when not at work, in the open air.

They certainly bred strong men in those days in spite of their insanitary dwellings.

But a comparison of these conditions with those of the modern colliery villages, described farther on, shows the enormous progress that has taken place in the housing of miners.

The modern miner's house has usually five rooms, namely, a kitchen, with a scullery containing a washing boiler or "copper," and a parlour on the ground-floor, with water-closet and coalhouse built in a yard behind, and three bedrooms upstairs, and sometimes a bathroom. The cost at prices prevailing in 1914, before the war, averaged about £290, or about 4d. per cubic foot for building alone, not including land, drainage, water supply, fencing, footpaths, roadway, and sewer, or architects' and surveyors' fees.[1]

This is the type of miner's house which was being generally built (as is shown in the examples hereinafter given) in the years immediately preceding the war, and it must be allowed that with water and gas or electric light laid on, it fulfils all reasonable requirements.

The three bedrooms permit of separate sleeping accommodation for the parents, and for the boys, and for the girls of the family.

For the newly married miner, or for a small family, a four-roomed house—kitchen, parlour, and two bedrooms—is amply sufficient, and in most colliery villages there are, of course, different types of houses varying in the accommodation they afford.

Miners' houses should be warm and free from draughts. During the last year or two the writer has visited a large number of miners' houses recently built in different districts, and the complaint which he has heard most commonly—though complaints have not been common—was of the prevalence of draughts. A miner, coming up from his work hot and tired, and sitting down to a meal as they often do before washing or changing clothes, wants to be kept warm and free from cold draughts.

An entrance lobby is useful, and the right position of doors and windows and fireplaces needs consideration.

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[1] The cost of building varies very greatly in different districts. This is well shown in Mr. Wilson's Special Report, Royal Commission on Housing in Scotland. The cost of a four-roomed cottage (see Fig., page 253) built of brick in blocks of two, including drainage, water supply, fencing, footpaths, roadway, and sewer, at prices prevailing in July 1914, varied in forty-seven different burghs and districts in Scotland, from £205, or 4·85d. per cubic foot at Glasgow to £330. 10s., or 7·82d. per cubic foot in county of Argyll.

These prices are based on the average normal rates prevailing in each district at July 1914.

This wide variation arises from various causes, such as the difference in the cost of bricks and cement and other materials, the distances that materials have to be brought, the rate of wages, and the output of work. For instance, the cost of bricks was 29s. to 35s. per 1000 at Glasgow, and 45s. at Oban.

A perusal of the bye-laws affecting the building of dwelling-houses, which are in force in a thickly populated mining district in Co. Durham, leaves one with the impression that in the case of *new* houses at any rate they are bound to be thoroughly satisfactory buildings. These bye-laws specify in considerable detail requirements as to the structure of walls, foundations, and roofs; chimneys and hearths; floors and staircases; the height of rooms; the windows and the ventilation; the space to be left about the building, the drainage, and the paving of yards and open spaces.

This elaboration has the drawback that it leaves little scope for individual judgment or initiative. The excessive stringency of the local bye-laws, in some districts, has undoubtedly checked building enterprise, and is one cause of the scarcity of houses.

At their new Blackhall Colliery, on the south-east coast of Co. Durham, where they are now raising about 1500 tons of coal daily, the Horden Collieries Ltd. are laying out a new village.

Plan on page 257 shows the lay-out.

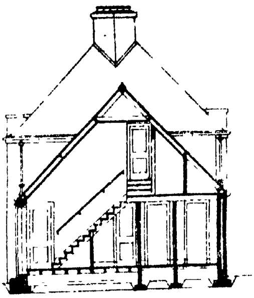
The public buildings indicated on the plan—workmen's institute, theatre, church, etc.—are still to be built, progress having been stopped by the war.

Four hundred and sixty-two houses had been built at November 1917 by the Colliery Co., and a good many more, including a number of shops, by private individuals.

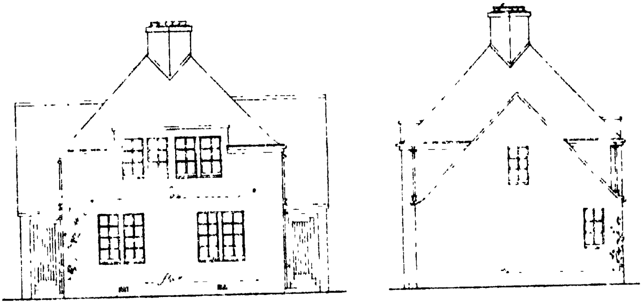
Of the houses built by the colliery owners, four classes may be mentioned here as being of the most approved designs. Certain features are common to all these houses. In all, brick is the material used, generally red pressed bricks for the fronts, and elsewhere a common brick, made by the colliery company, and supplied to the building contractor at a price of 28s. a thousand.

The outside walls are 11 in. cavity walls, and the inside 9 in. solid brickwork.

The roofs are of second quality Bangor slates, 14 in. by 10 in., laid with a lap of 2¾ in. All houses are provided

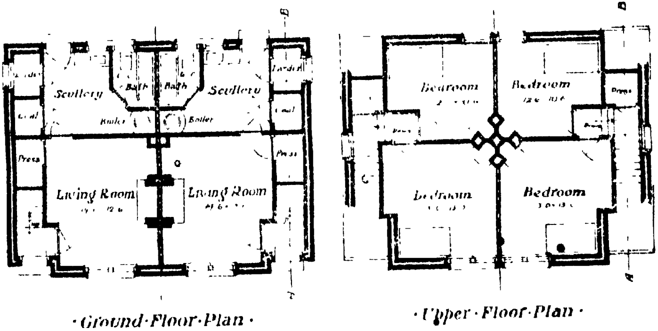


·Section A·B·



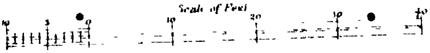
·Front·Elevation·

·Side·Elevation·



·Ground·Floor·Plan·

·Upper·Floor·Plan·



Four-roomed cottage built in blocks of two (Mr. John Wilson's Special Report, Royal Commission on Housing in Scotland, 1914).

(*Reproduced by permission of Controller of H.M. Stationery Office.*)

with back yards, in the far corner of which, at a little distance from the house, are a coalhouse and an earth-closet. Earth-closets are preferred to water-closets, because the latter are so often put out of action, and the drain pipes stopped up, by the various articles put into them by the tenants. But it must not be assumed that this is always so. In many new mining villages, as will be seen from the examples given farther on, water-closets have been installed.

In all the houses the rooms, both on the ground floor and on the first floor, are 9 ft. high.

Water is laid on to every house, and supplied gratis by the owners; and for lighting purposes electrical current is supplied by the owners at a charge of 6d. or 8d. a week, according to the size of the house and the number of lamps. No meters are installed in the houses. The lamps are supplied by the owners to their workmen at about cost price.

All the machinery at this colliery being electrically driven, the atmosphere is remarkably pure and free from smoke. The inhabitants of the village enjoy a fine sea-view, and breathe the bracing air of the north-east coast in all its purity.

The houses are allowed rent free to the colliery workmen as part of their wages, according to the custom which prevails in Durham and Northumberland, and a load of coals is allowed free every fortnight in the winter months, and every three weeks in the summer.

All the roads and footpaths are tar-macadamed, which tends to cleanliness and freedom from dust.

Class I. (see Plan, page 258) is a four-roomed house, having on the ground-floor in front, a living-room 14 ft. by 12 ft. 3 in., and behind, a kitchen 14 ft. by 11 ft. 3 in., and built out into the back yard, and entered through a door from the kitchen, a wash-house 6 ft. by 6 ft. 9 in., containing a "set pot," and behind that again a pantry 6 ft. by 3 ft.

On the first floor are two bedrooms 14 ft. by 10 ft. and 13 ft. 6 in. by 10 ft. 10 in. in area respectively, both provided with fireplaces.

The frontage of each house is 14 ft. 9 in., and the gable about 26 ft., and a cemented yard extends 24 ft. at the back.

The contract price of building this house, just before the war, was £160, which works out at 4d. a cubic foot.

The cost of making tar-macadam roads and footpaths, and of cutting and laying drains, and of the water-supply pipes from the reservoir to the village, with valves and hydrants, etc., comes to £19 a house.

The width of the street in front is 36 ft., and of the street at the back 24 ft., and in this figure of £19 the cost of the streets at the ends of the rows are apportioned to each house in addition.

Class II. (see Plan, page 259) is a five-roomed house. On the first floor are three bedrooms, one in front 13 ft 4½ in. by 14 ft. 6 in., and two behind 8 ft. 4½ in. by 10 ft. 9 in., and 8 ft. 3 in. by 7 ft. 5½ in. in area respectively. The two larger bedrooms are provided with fireplaces.

The house has a frontage of 17 ft. 9 in., and a gable of about 27 ft., and a cemented yard extends about 23 ft. at the back. There is also a little garden ground in front varying in size.

The contract price for building this house was £190, which works out at 3·8d. per cubic foot.

The cost of tar-macadam roads and drainage, etc., as described before, comes to £22 a house, the width of the street in front in this case being 43 ft., and the frontage of the house being greater.

In comparison with Class I., this house is larger by 3 ft. in the frontage and 1 foot in depth. The extra space is put into the kitchen and the front bedroom, and there is an additional bedroom.

Cupboards are provided on each side of the kitchen range, a closet under the stairs in the sitting-room, and a closet in the front bedroom.

Class III. is a rather larger five-roomed house than Class II. This house has a 17 ft. 9 in. frontage, and a gable of 28 ft., not including the projecting portion behind.

There is a garden in front 17 ft. 9 in. by 14 ft., with a cement footpath, and a cemented yard extends 36 ft. at the back of the house.

The cost of building was £257, which works out at 4·1d. per cubic foot.

In comparison with Class II., it provides larger bedrooms, and a bath, which the other does not. But the projecting bedroom on the first floor—though it is often to be found in workmen's cottages—must be a cold room with so much outside wall, and also must cut off to some extent light and sunshine from the back of the house.

It requires, too, a considerably larger quantity of bricks and mortar, and on the whole Class II. is better value for the money.

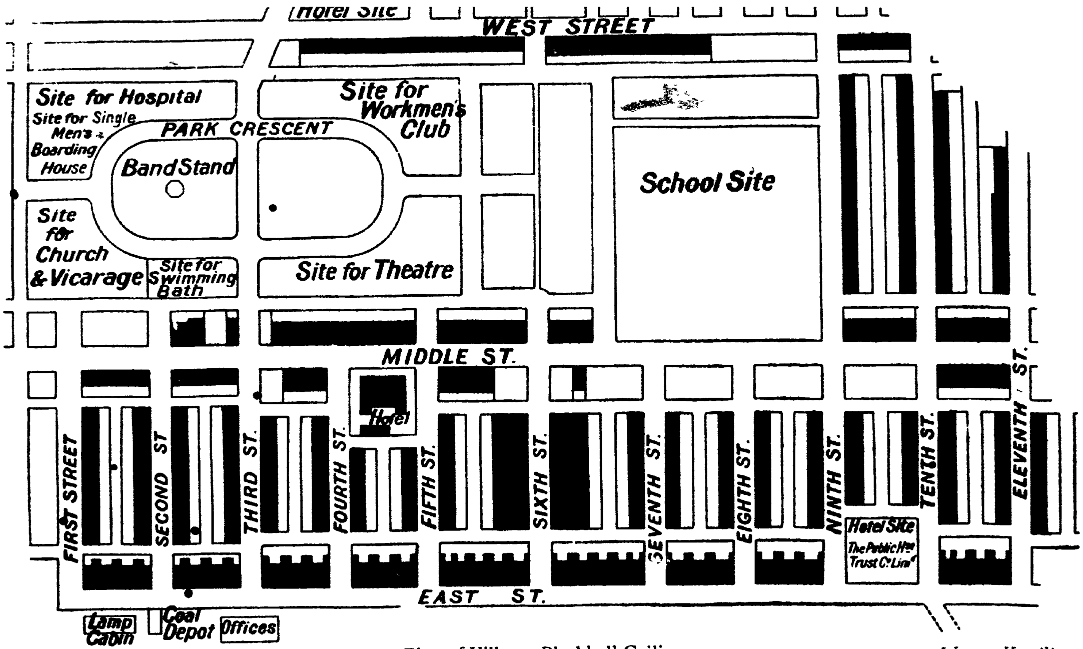
"It should always be remembered that as a room or house approaches a square on plan, so does the cost decrease. The house that is narrow-fronted and deep on plan may have the same length of walling to enclose it as that enclosing a house which is practically square on plan, but the former has about 25 per cent less floor area than the latter" (John Wilson, F.R.I.B.A., Special Report, 1917, Royal Commission on Housing in Scotland).

A table-topped bath in the scullery may be better than no bath at all, but it does not encourage the regular taking of baths. The scullery is wanted for so many other things. A separate bathroom entered from the scullery is certainly an improvement, and being near the washing boiler allows of a supply of hot water from that source.

Class IV. is a house designed for colliery officials.

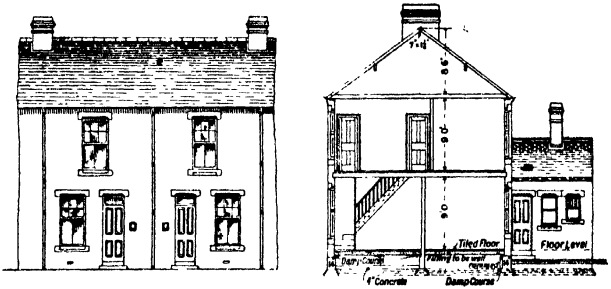
It contains on the ground-floor, a parlour 16 ft. by 13 ft. with a bay window, a sitting-room 14 ft. 4 in. by 15 ft., a kitchen-scullery 10 ft. by 12 ft. 9 in. entered from the hall, and a pantry 10 ft. by 3 ft. 9 in. On the upper floor are three bedrooms, 12 ft. 10 in. by 15 ft., 14 ft. 4 in. by 13 ft., and 8 ft. by 11 ft. in area respectively, a bathroom 10 ft. by 8 ft. 10 in., and a water-closet.

There is a vestibule 4 ft. 10 in. by 4 ft., and a good-sized hall.



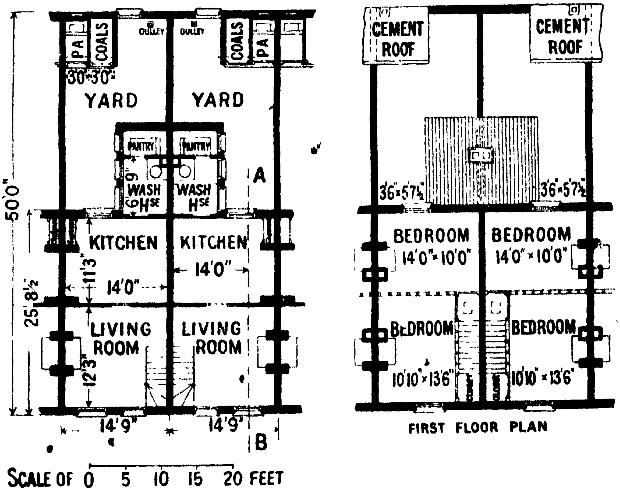
Plan of Village, Blackhall Colliery.

[James Hamilton.



FRONT ELEVATION

SECTION A B



FIRST FLOOR PLAN

GROUND PLAN

Plan of Houses, Class I., Blackhall Colliery.

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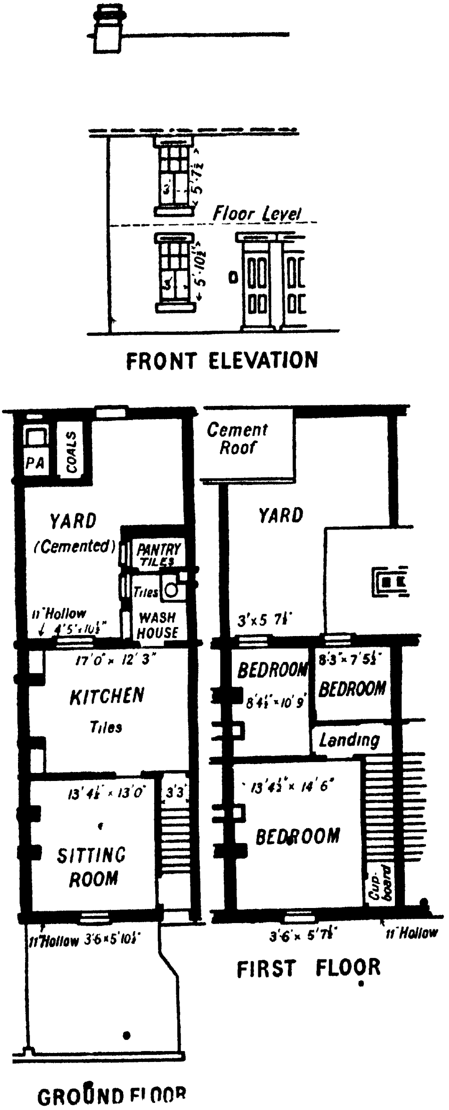
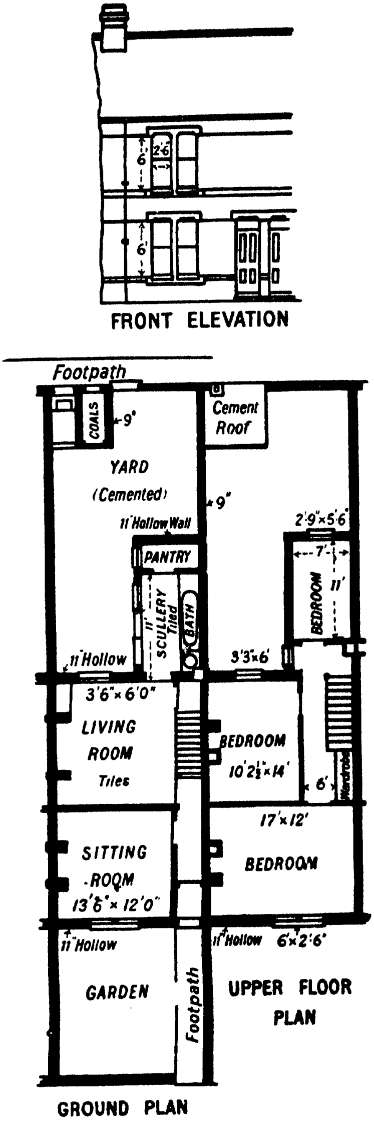


Plan of Houses, Class II. Blackhall Colliery.

[*James Hamilton.*



Plan of Houses, Class III., Blackhall Colliery.

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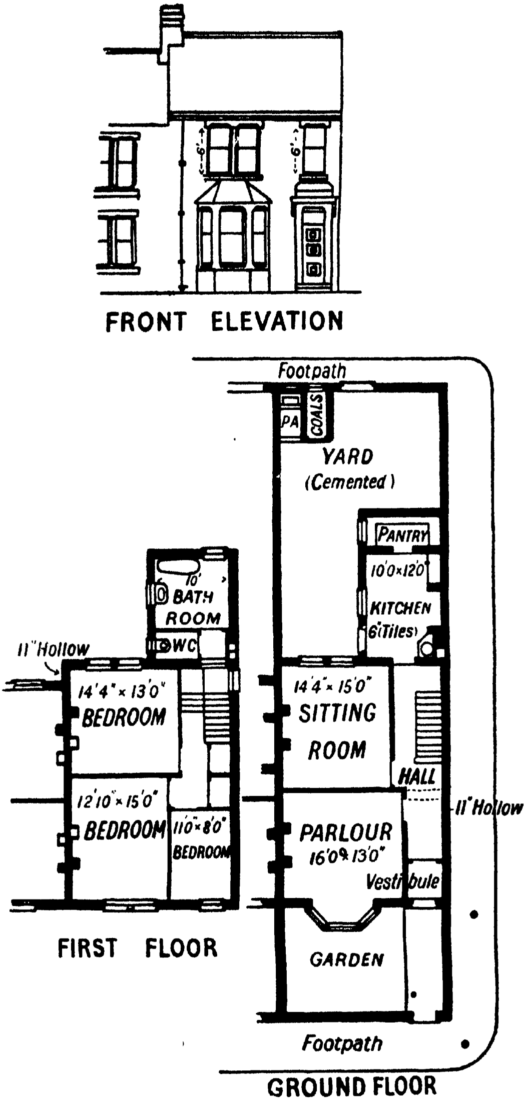


FRONT ELEVATION

FIRST FLOOR

GROUND FLOOR

Plan of Houses, Class IV., Blackhall Colliery.

[*James Hamilton.*

The house has a frontage of 22 ft., and a 30 ft. gable, and a back yard extending 32 ft.

These officials' houses are built at each end of rows of the other houses, and serve thus to relieve somewhat the monotony of outline.

They cost for building £386, or 4·3d. per cubic foot.

It will be noticed that not all the houses are provided with gardens.

Gardening is a useful and healthy hobby which deserves every encouragement, but it is not every miner who has any skill or inclination for it. Nowadays there are many counter-attractions. Ill-kept and neglected gardens are an eye-sore in any village. In laying out a village, the best plan seems to be to allow for gardens to a considerable number of the houses, and to set apart ground also for allotment gardens, so that every man who wants a garden and will take care of it may have one. Of course it is not always possible to get the necessary land for this. Well-kept gardens require a settled community; with a shifting population they are sure to be neglected.

House property has a special attraction as an investment for the thrifty and capable miner who has saved money, and the best of them like to be the owners of the houses in which they live. Unfortunately this method of self-help has been weakened by the modern tendency to look for help to the State or to Local Authorities.

HOUSES BUILT BY MINERS

In Co. Durham before the war, houses were being built to a considerable extent by the miners themselves.

An instance may be given.

A miner who has worked regularly in a coal mine from boyhood, and has risen to the position of a deputy-overman, has interested himself for some time past in house property and has made money out of it.

In 1911, a few years before the war, he purchased a two-acre field on easy terms, having a frontage of 60 feet on one main road and 40 feet on another, situated in the open country. On this site he has built fifty-one good substantial houses with gardens, which have been in great demand among the miners of the district, most of them having been sold as soon as they were built.

The man who carried through this enterprise is a good specimen of his class, level-headed and self-reliant, and he made a point of getting good material and of having the work thoroughly well done. In fact, he dismissed one building contractor for scamping some of the work! He knows what sort of a house the average working miner wants.

The outside walls are 14 in. brickwork of red pressed bricks, and the partition walls 9 in. common brick. The little gardens in front are enclosed by a strong iron palisading placed on a stone coping as a foundation.

Some of the houses are four-roomed and some five-roomed.

The four-roomed houses are shown on Plan A, page 267.

The main building covers an area of 476 sq. ft., 17 ft. front and 28 ft. gable. The garden in front is about 120 sq. ft. (17 ft. by 7 ft.) in area, and there is a paved yard behind 17 ft. by 21 ft. = about 360 sq. ft. enclosed by a wall. In this yard is the scullery 9 ft. by 7 ft., adjoining the house and entered from the kitchen, and in the far corner a coal-house and an earth-closet.

These earth-closets are constructed, according to the regulations of the District Council, to form a receptacle for the ashes from the house fires, and are cleaned out regularly every fortnight, access being from the road outside through a metal door let into the wall surrounding the yard.

The ground-floor is occupied by a kitchen 12 ft. by 13 ft. by 9 ft. high, and a living-room 12 ft. by 11 ft. by 9 ft. high rather smaller than the kitchen. Upstairs are two bedrooms.

A good point about these houses is the ample supply of roomy cupboards, including one in the kitchen occupying the recess to the right of the fireplace, one under the stairs with a door into it from the kitchen, one in the bedroom over the kitchen, and a wardrobe (a wooden fixture) on the landing at the stair head.

Water and gas are laid on to each house, and are supplied by Public Companies. The charge for water is 3d. per week, and the gas is charged for on the penny-in-the-slot system. The Gas Company put in the fittings, and keep them in repair.

The selling price of these houses before the war, as a freehold, was £205, and they have been readily bought by miners at this price.

Their rateable value is £8, and the rates amount (in 1916) to £2. 12s. per year, which is 6s. 6d. per £.

Let by the week, the rent is 5s. 6d., the tenant paying besides for water and the rates.

The making of the roads and the drainage were carried out by the District Council, and the cost of this works out at about £12 per house.

The five-roomed houses cover a rather larger area, and have three bedrooms upstairs, two of which are provided with fireplaces. They are sold for £215.

The cost to an individual owner of keeping in outside repair well-built houses of this class over a period of twenty years may be put at about £1 a year. Colliery companies sometimes do it for a good deal less than this over a large number of houses, as they keep joiners and masons and plumbers regularly employed.

In the Report of the Royal Commission on Housing in Scotland (1917), some figures are given, bearing on this point, which were supplied by Messrs. Wm. Baird & Co. On 976 houses built in Lanarkshire since 1874, and costing £128,593, the annual cost for repairs and materials amounted to £1054, or 0·82 per cent of the capital. This is rather more than £1 per house per year, but it covers a period of forty years.

In Mr. Wilson's Special Report (1917), Royal Commission on Housing in Scotland, he remarks as to "Repairs and Maintenance": "If the officials of a Local Authority manage the property, 7½ per cent of the annual rental seems sufficient. Private owners usually allow 10 per cent for this work, but opinions vary considerably as to the charge. It will be found generally that the main items in the annual cost of repairs are for slater, plumber, and painter work."

Taking the annual rental to be £15, 7½ per cent is 22s., and 10 per cent is 30s.

From £1 to £1. 10s. per house per year seems therefore to be a reasonable cost for repairs and maintenance of this class of house.

"It is false economy to save unduly on the initial outlay on the construction and materials of a building, as the result is certain to be increased expense in maintenance."

BUILDING BY CO-OPERATIVE SOCIETIES

In the mining districts of the north of England, much has been done by the Co-operative Store Societies to help miners to build or to buy houses. These societies are controlled by committees, on which the miners are largely represented. In many pit villages nearly all the miners are members of the Co-operative Society and purchase all their requirements in food and clothing at the local stores.

The system of cash down for goods supplied, and of returning dividends to the members in proportion to their purchases, and of paying 5 per cent compound interest on dividends left to accumulate, is an excellent system for encouraging thrift and the habit of saving. Many a miner has laid by a considerable sum of money through his Co-operative Society.

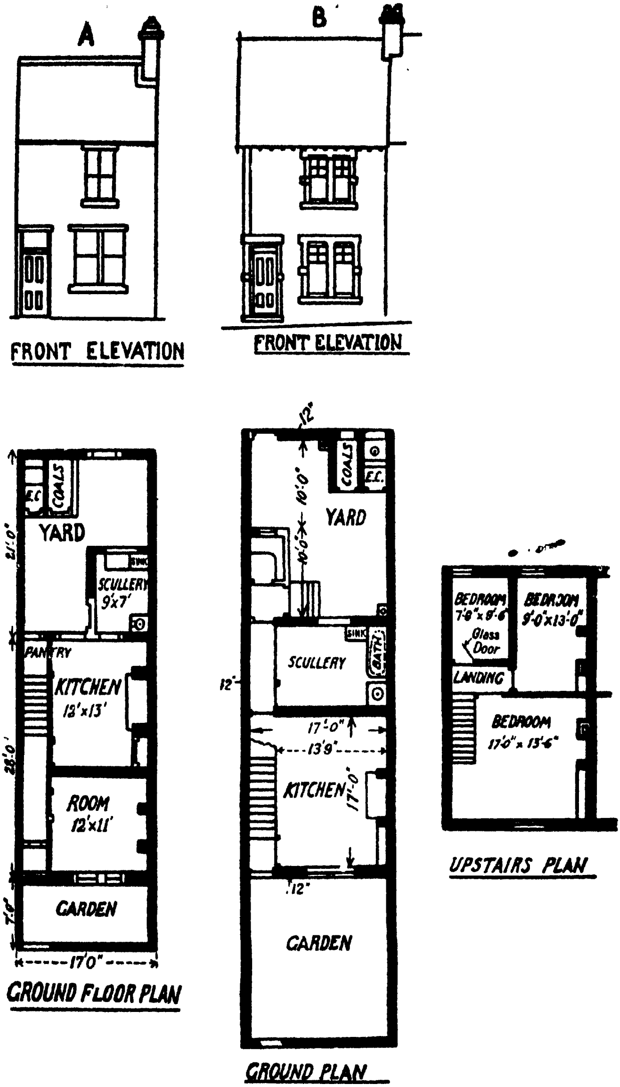
Houses are much in demand in many mining districts, and most of these societies have turned their attention to meeting this demand. This they do both (1) by building houses themselves, and giving the occupying tenants the option of becoming the owners by paying an increased rent over a given period of years, and also (2) by advancing money to a member wishing to build a house.

For instance, a Co-operative Stores Society in Co. Durham with a membership of 1891, chiefly miners, has spent about £25,000 on building houses prior to the war. The type of house usually built is much the same as that shown on Plan (page 267, house A), with a bathroom in addition, having on the ground-floor a parlour, a kitchen and scullery, with a paved yard at the back containing the usual out-houses, and two bedrooms and the bathroom upstairs.

A member wishing to purchase a house deposits one-fifth of the cost—but since the war this has been reduced to one-tenth—and repays the remainder at the rate of 13s. 4d. a month for each £100 or fraction thereof plus 4⅙ per cent for interest on the outstanding balance each quarter year.

Per £100 the quarter year's interest at 4⅙ per cent is £1. 0s. 10d., and the repayment for the same period at 13s. 4d. a month is £2, so that at the end of the first quarter year the balance amounts to £99. 0s. 10d., on which the interest is charged for the succeeding quarter, and so on, the outstanding balance being reduced each quarter. Under this method a member becomes the owner of the house in a period of about seventeen years. Of course he may make larger repayments if it suits him, and thus become possessed of the house more quickly. During the period of repayment, he is responsible for all repairs to the house, and he pays the rates and taxes.

Another large Co-operative Society in the neighbourhood of Newcastle-upon-Tyne, whose present membership is 11,613, of whom nearly 7000 are employed at collieries, has spent during the last thirty-five years more than £100,000 on building houses, and has advanced more than twice this sum to members for the purpose of building houses. In the latter case the rule of this society is to advance at the rate of four-fifths of the total value, the valuation being made by the valuers of the society. The repayment is based on a seventeen years' purchase system, the monthly payments being 13s. 4d. per £100, which covers the redemption of the capital and interest at 4⅙



Plan of Houses in Co. Durham.
A, built by a miner ; B, built by a colliery company.

per cent on the outstanding balance each quarter year—as just explained.

As regards the houses built by the society itself, the first, which were built more than thirty years ago, were three-roomed houses, having on the ground-floor a kitchen living-room, a back-kitchen scullery, with a yard and the usual outhouses, and two bedrooms on the first floor. These built in rows cost £146 each, some of them, and others £170. Recently they have been sold for £220, and in one case as much as £240 has been given.

The last houses built by the same society just before the war are five-roomed houses—a kitchen and a living-room on the ground-floor with the usual offices, and three bedrooms and a bathroom on the first floor. The main building covers an area of 600 sq. ft.—20 ft. front by 30 ft. gable.

They have a paved yard behind which extends into a piece of garden ground, the area of yard and garden being about 1200 sq. ft., and in front they have also a little garden about 200 sq. ft. in area.

They are built of concrete blocks, the outside walls being 11 in. thick and consisting of two 4½ in. blocks with a 2 in. cavity between. On the outside it looks like ashlar, and in conjunction with their red-tiled roofs gives the houses an attractive appearance. Their strength and durability are quite satisfactory, if the concrete blocks are properly made with good cement and the right mixture, but this method of building has not been found to be cheaper than brickwork.

"A cavity wall of concrete is never so satisfactory as one of brick, as the former absorbs water much more readily than the latter."

"Cavity walls built of concrete blocks have not been found to be cheaper in cost than those of brick. This may, however, be due to a lack of knowledge of the making of concrete blocks" (John Wilson Special Report, 1917, Royal Commission on Housing in Scotland).

But concrete for houses is strongly recommended by some authorities.

"Cottages built of concrete blocks surpass all ordinary types of construction for cleanliness and all hygienic conditions, as well as for durability and rapidity of construction, and they are more economical to build; but . . . the blocks must be made in the proper way, and the construction details must be correct" (see *Times*, June 9, 1919, Letter by Major-General A. S. Collard).

At the Crayford Garden Village, built under a Public Utility Housing Scheme, 400 houses were built of concrete blocks with continuous-cavity walls, and have proved quite satisfactory.

The choice of material for building, whether brick or concrete or stone or other, should be guided by the readiness with which it can be obtained in the particular locality.

The cheapest material is dry compressed earth, or what is known as *pisé de terre*.

Mr. St. Loe Strachey of *The Spectator* and others have shown that good cottages may be built with earth walls 18 in. to 24 in. thick made solid by a process of ramming between wooden casings (see *The Spectator*, June 7, 1919).

The total cost of the concrete houses built by the Co-operative Society was about £420, which includes £35 for the site. They are assessed for rates at £15.

To secure a house for himself, a member of this society makes a deposit of one-twentieth of its value, and payments at the minimum rate of 10s. per £100 per calendar month. This allows for the payment of the full price with interest at 4½ per cent on the outstanding balances in a period of about thirty-two years. These are minimum terms of repayment, which he may accelerate according to his means.

The advance from three-roomed houses costing about £160 to five-roomed houses with a bathroom costing £420 is typical of the progress made in miners' housing accommodation during the last forty years. But it should not be overlooked that the cost of building has increased much during the ten years preceding the war.

Plan B, page 267, shows a miner's house which has been built in considerable numbers by a colliery company in Co. Durham.

It is similar in size and in cost of building to A shown on same Plan, but the interior arrangement is different. The ground-floor is occupied by a large kitchen living-room, and a large scullery in which is a bath, provided with a hinged wooden lid or cover, which can be used as a table when the bath is not wanted.

Upstairs are three bedrooms, two of which are provided with fireplaces. There is a large paved yard behind —20 ft. by 17 ft. inside dimensions—in which are the pantry and the usual outhouses.

There is some difference of opinion as to whether it is better to use the ground-floor area in this way for one large kitchen living-room and a large scullery, or to provide a separate living-room by reducing the size of the kitchen as shown on Plan A, page 267. Some contend that the separate living-room not infrequently becomes a sort of state apartment seldom entered and of very little use, and that miners' families prefer to be together in one large well-warmed room. The modern tendency, however, is in favour of a separate parlour or living-room, and most miners now seem to prefer it.

GUISBOROUGH

Plan (page 271) shows a neat block of four miners' cottages built at Guisborough in Cleveland to the design of Messrs. Hedley & Douglas Pollock, architects, of 15A Baker Street, London, W.

Built in the early part of 1913, the cost, exclusive of land and architects' and lawyers' fees, was for the end houses, A and D, about £220 each, and for the middle houses, B and C, about £200 each.

Accommodation.—On ground-floor, parlour, kitchen, scullery, and bathroom, with hot and cold water, and three bedrooms on first floor.

Materials.—Common brick walls, unplastered on the

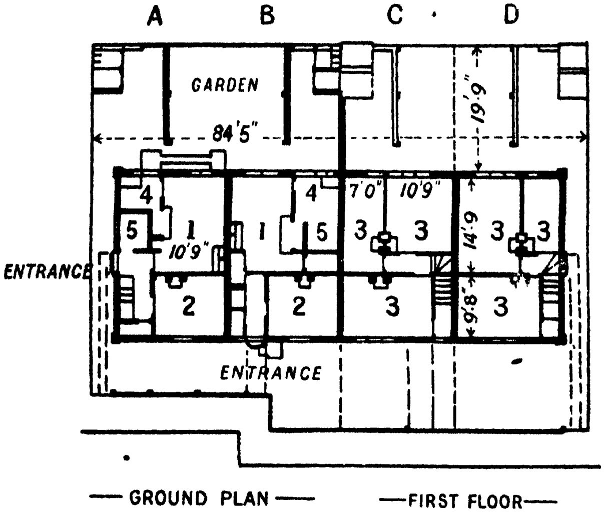
PLATE XII

FOUR MINERS' COTTAGES AT GUISBOROUGH, CLEVELAND

inside and colour-washed externally and internally. Pantiled roof.

The total cost works out at about 5d. per cubic foot.

The cottages A and D are let at 7s. 6d. a week and



Plan of Houses, Guisborough.

1, Kitchen; 2, Parlour; 3, Bedroom; 4, Scullery; 5, Bathroom.

[*Messrs. Hedley & Douglas Pollock.*

B and C at 7s., all rates and taxes, including water rate, being paid by the owner, not the tenant.

COTTAGES FOR AGED MINERS

An excellent movement has been on foot for a good many years in Northumberland and Durham, to provide cottages for the aged miners who are past work, and their wives.

This provision for the veterans of the industry is evidence of the spirit of kindliness and of self-help which actuates the best type of north-country miner. It is a fine example of the hand-clasp between "Labour and Love," which is the motto of the Durham Aged Mineworkers'

Homes Association. It has been described by Lord Joicey as "the most remarkable philanthropic work done by any body of workmen." Undoubtedly, it owes a great deal of its success to its first President, the late John Wilson, M.P., D.C.L., the secretary for so many years of the Durham Miners' Union. He, with the present Dean of Worcester, Dr. Moore Ede, then Vicar of Gateshead-on-Tyne, and a few others, inaugurated the scheme in 1898, and until his death in March 1915 it always received Mr. Wilson's hearty and untiring support.

The controlling body of the Durham Aged Mineworkers' Homes Association consists of a President, a Secretary, and an Hon. Treasurer, and a committee, at present numbering twenty-seven members, representative of the mineworkers, and including a few mine managers. The Hon. Treasurer at the present time is Mr. J. J. Prest, the general manager of Horden Collieries Ltd.

There are a number of district committees throughout the county engaged in the promotion of schemes for providing cottages in their own localities, and each district committee has a representative on the General Committee.

At January 1915, the Association owned 475 cottages, which were valued at £41,190. Generally they are one-storied, two-roomed cottages, with a little garden ground in front, built in rows of ten or twelve together.

Many of the tenants have worked at the mines for periods of fifty to sixty years. Four of them can claim seventy years of service.

The oldest tenant as yet on record, Stephen Barrasford, died in June 1917, within a few days of his ninety-sixth birthday. He began work as a trapper boy down the Lamp Pit, Black Fell, Co. Durham, at the age of five years eleven months, and, except for a short break, he continued working down the pit till he was seventy-eight years of age. About fifty of his descendants have been engaged in our Forces during the war. Two great grandsons have been killed in action.

During the year 1914, thirty-eight new cottages were opened, and over fifty were nearing completion at the end of the year. One hundred and fifty-three houses were being built at ten different places in the county.

As stated in the Annual Report of the Association for 1914, the total cash income of the Association since its foundation in 1898 has been about £80,000, of which about £46,000 has been contributed by the miners. The remainder has been subscribed by colliery owners and the general public.

The following figures taken from the audited balance sheet for the year ended December 31, 1914, indicate the extent of the movement:—

Receipts—	£	*s.*	*d.*
Mineworkers' contributions	9,923	10	3
Private subscriptions and donations	2,899	19	4
Rents from cottages [1]	195	17	8
Rose Day (a special effort on Miners' Demonstration Day)	236	19	5
Sundry receipts from football competitions, concerts, collection Durham Cathedral, etc.	199	2	7
Interest on investments	124	17	9
Sales of lands	65	17	0
	£13,946	4	0

A total of nearly £14,000, and a credit balance of £2489. 11s. 10d., was brought forward from the previous year's account.

1914 was a record year, and the contributions of the mineworkers, who include enginemen, cokemen, deputies, and mechanics, amounted to close upon £10,000.

Turning now to the Expenditure side of the Balance Sheet, there was spent on the—

Building of cottages	£14,553	17	2
Repairing do.	199	15	4
Coal and leading [2]	1,769	3	1
Rents, rates, taxes, insurance, etc.	622	17	8
Wages	186	7	1
Secretary's salary	117	0	0
And a few other small items brings up the total expenditure for the year to	£17,885	8	10

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[1] Paid by coal-owners who have leased cottages from the Association for men employed at their collieries.

[2] Firecoal is supplied to all the tenants free of charge. The cost of it to the society during the year 1916 amounted to £2226.

The results already achieved by this movement [illegible] what can be done by the friendly association of Labour and Capital in promoting a common object for the benefit of Labour.

The Doncaster district, where so many large collieries have been started within recent years, affords several good examples of mining villages of the modern type.

WOODLANDS VILLAGE

The Woodlands Model Village, made by the Brodsworth Main Colliery Co. Ltd., under the guidance of their late chairman, Sir Arthur Markham, Bart., M.P., is unique as a colliery village both in its natural site and in the way in which it has been laid out.

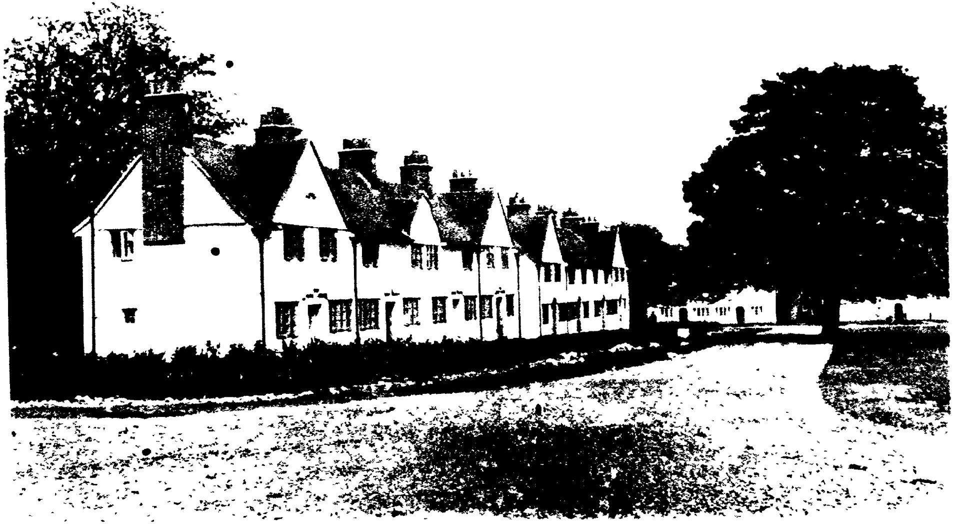
The site is a well-timbered estate of 120 acres, mostly park land with fine old trees, and includes a mansion house and a lake. On it, well distributed over the whole area, there have been built 964 houses, giving an average of about eight houses to the acre. Ample space prevails everywhere. The tenants are all employees of the colliery company, and the total population numbers about 6600, an average of nearly seven per house. (See Plan, page 275.)

The houses are built semi-detached or in blocks of three, four, or five houses. There are more than twenty different types of house presenting a considerable variety of tasteful design. They may justly claim to be architecture, as distinguished from mere building. The architect is Mr. Percy B. Houfton of Chesterfield, who gained the first prize in competition for the design of a cottage not to cost more than £150, inaugurated by the *County Gentleman* in 1905, in connection with the Letchworth Garden City.

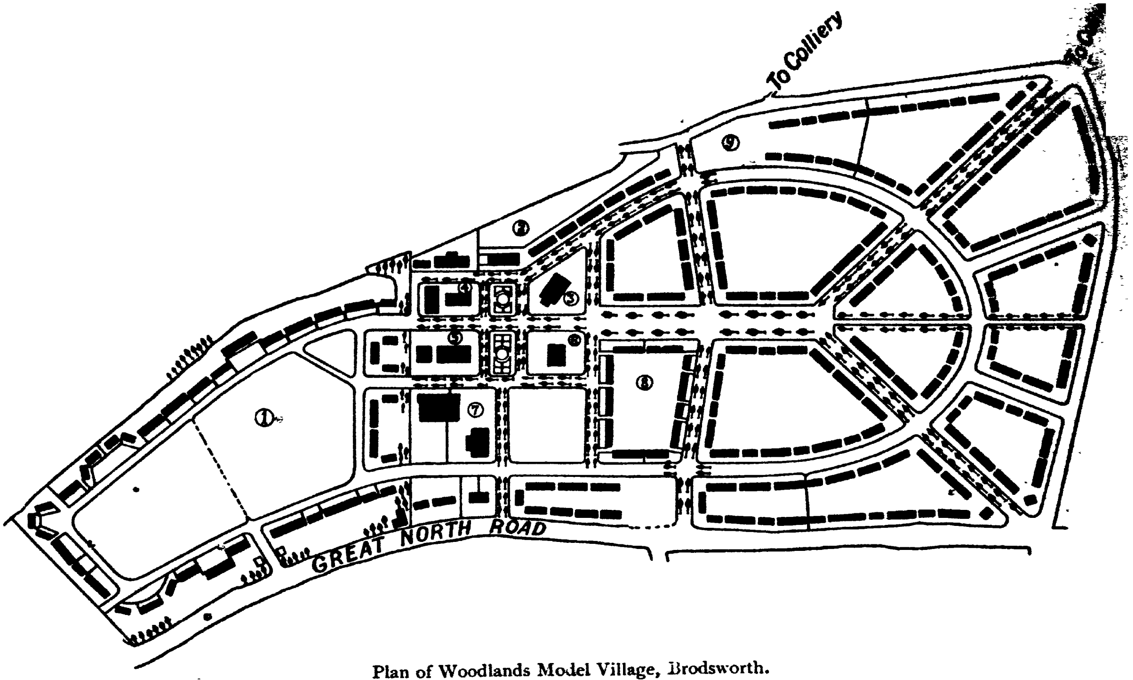
Rough-cast has been largely used in the outside finish of the houses.

Arranged in broad tree-lined avenues and curving crescents, interspersed with wide green spaces, they are attractive in appearance and in striking contrast to the dull monotony

PLATE XIII



WOODLANDS VILLAGE

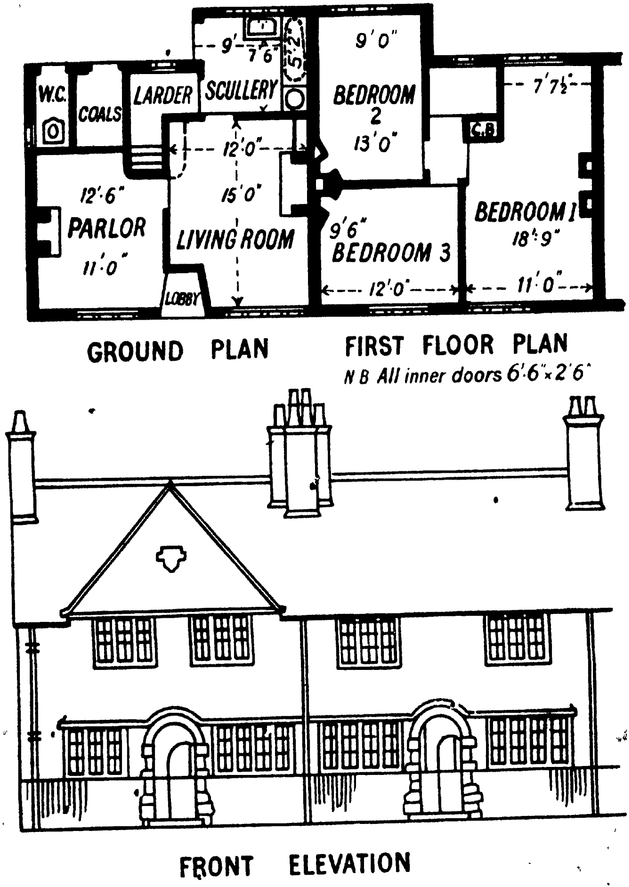


Plan of Woodlands Model Village, Brodsworth.

1, Woodlands Green ; 2, Railway Sidings Goods Yard ; 3, Church ; 4, Wesleyan Chapel ; 5, Primitive Methodist Chapel and Schools ; 6, Vicarage ; 7, Schools ; 8, Open Green ; 9, Site for Swimming Bath.

[*Percy B. Houfton.*

of long straight rows of brick houses, of which so many pit villages consist. There are no ashpits or refuse heaps, each house being provided with an ash-bin, the contents of which



Plan of Cottages, Brodsworth.

[*Percy B. Houfton.*

are removed by cart three times a week. A special feature is the absence of yards and outhouses, which sometimes form a harbourage for dirt and refuse. Generally the fronts and backs of the houses form unbroken lines, and there are no projecting buildings to shut off light and air. Most of the houses have flower gardens in front, and the company gives prizes yearly for the best gardens.

All the houses are provided with three bedrooms, each having a fireplace, and with a scullery, a pantry, a coal-house, and a water-closet. The smallest size, the rent of which is 5s. 6d. a week, contains besides one large kitchen living-room. The next size (see Plan), which is rented at 6s. 3d. a week, has in addition a parlour. For 6s. 9d. a week a separate bathroom, with hot and cold water supply, is provided in addition. A still larger house rented at 7s. 6d. a week is provided for colliery officials.

These rents cover the water supply and the rates and taxes and all repairs, which are paid for by the company.

The lighting is by gas, which is supplied by a public gas company, and paid for by the tenant on the penny-in-the-slot system.

The rents are taken off from the men's wages each week at the pay office, an arrangement which saves all parties a great deal of trouble.

The mansion house has been turned into a workmen's club, the membership of which numbers 600 to 700. The subscription is 1s. a quarter year. It is managed by a committee composed of six workmen's representatives and six representatives of the Company, with the Agent of the Colliery Company, Mr. J. T. Greensmith, as chairman.

On the ground-floor is a reading-room and library, a billiard-room, two other rooms fitted with small tables for card games or dominoes, and a bar. Good liquor is provided, to be paid for when taken, and all profits are devoted to the interests of the whole village community. Upstairs there is a room which is set apart for the practisings of the village band, and there are bedrooms which can be used under certain conditions by members of the club and by visitors.

In the garden outside are two good bowling greens and plenty of seats.

In an outbuilding at the back is kept a modern and well-equipped fire engine. There is a capable fire brigade composed of employees of the company, who keep themselves competent by weekly drills.

The village includes a handsome church with sitting accommodation for 500, the gift of the late Mr. Charles Thellusson of Brodsworth Hall, the lessor of the coal; Primitive and Wesleyan Methodist Chapels; well-built schools, with accommodation for 900 children; extensive playing grounds, including football, cricket, and hockey grounds, a bicycle and running track, and a handsome brick pavilion.

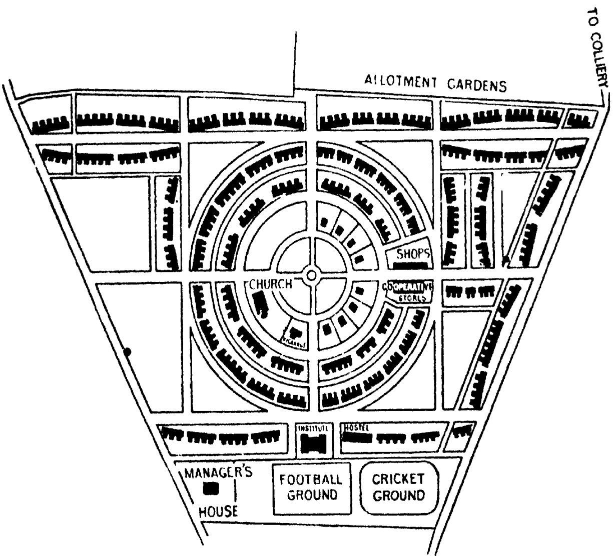
Altogether it may justly claim to be a model pit village.

The cost of building these 964 houses was stated by the late chairman of the Brodsworth Main Colliery Co. Ltd., Sir Arthur Markham, Bart., M.P., at a shareholders' meeting, to be £208,000, an average of nearly £216 a house. The company is fortunate in having a good bed of brick clay close to the pits, and brickworks capable of producing about 30,000 bricks a day, which no doubt helps economical building. Taking into account the cost of the site, of making roads, of drainage, water supply, etc., all of which have been undertaken by the Colliery Company, the total cost must have been considerable. But given a colliery with valuable coal seams which can be worked at a good profit, and with a long life before it, there can be little doubt that from a purely business point of view the expenditure is justified. The health and happiness and efficiency of work-people cannot be expressed in £ s. d., but apart from higher considerations they are a valuable asset in any industrial enterprise.

MALTBY AND ROSSINGTON

The villages at Maltby and Rossington Collieries in South Yorkshire, which are about six miles apart, but under the same control, are a good example of a miners' village of the best modern type. They have been laid out so as to secure the best modern conditions with the maximum of economy.

Maltby is the older village. At Rossington, building was begun towards the end of the year 1912, but was stopped by the war. They are both laid out on the same lines, but Rossington has the advantage of improvements dictated by experience, consisting chiefly in the provision of more open spaces and more garden ground about the houses.



Rossington Village. *[M. Deacon, M.I.C.E.*

The site covers an area of 84 acres, and the scheme allows for the building of 800 houses on this area, or about ten houses to the acre.

At the centre of the site (see Plan) some five acres of ground are reserved to be laid out as a public park with a bandstand in the middle. Crossing it are two roads at right angles to each other, which are extended across the whole site. Round this central park are three concentric circles of houses, at intervals of about 150 feet between the circles, leaving room for gardens and roads between. The innermost circle next the park consists of semi-detached houses for officials. The accommodation is—on ground-floor, kitchen and scullery and a sitting-room, with the usual outhouses, and a bathroom; three bedrooms upstairs, and an attic story above where there is one bedroom with a window in the gable.

These houses cost at pre-war prices about £250 for building alone.

In the next circle the houses are built in blocks of six and eight. The frontage of each house is 20 feet, the gable 22 feet, and there is garden ground behind each house about 40 feet deep by 20 feet.

The accommodation is, on the ground-floor, a kitchen and scullery and pantry and a parlour, and upstairs three fair-sized bedrooms and a smaller one. Two of the bedrooms are provided with fireplaces.

A bathroom and a coal-house and a water-closet are provided in a projecting portion of the building on the ground-floor, with access from the kitchen to the bathroom.

Materials.—The outer walls are of 9 in. brickwork; red bricks; division walls on ground-floor 4½ in. brickwork, and upstairs the division walls are built of a concrete material consisting of coke-breeze ground and mixed with cement made in slabs 3 ft. 6 in. by 1 ft. 6 in. by 2 in. thick. This forms a firm wall and is preferred by some to lath and plaster stoothing.

Roofs.—Some of slate, and some of red tiles.

The yards are asphalted, and an asphalt path runs down the centre of the garden to the gate.

Cost.—The contract price before the war was £185 a house.

Rent 6s. 11d. a week, which includes rates and taxes and water. Water and gas are laid on to each house, the gas being provided by a public company on the penny-in-the-slot system.

The houses in the next circle are a little smaller, having a 17 ft. frontage in place of 20 ft. The accommodation is much the same as to the number of rooms, but they are rather smaller. There is a small bath in the scullery, with hot water laid on from the "copper," as it is sometimes called, or "boiler," or "set pot." The scullery and coal-house and water-closet are in a projecting portion of the building. The material is the same as in the houses of No. 1 type.

The contract price for building these houses was £165.

They are let at a rent of 6s. 9d. a week, which includes rates and taxes and water as before.

The cost per cubic foot for building alone works out at 3½d.

These two types of houses are those which experience has shown to be preferred, but another type has been built to some extent, with a 13 ft. front, and one of the three rooms on the first story built over the scullery in the projecting portion of the building. A drawback to this—as already mentioned—is that it shuts off light and sunshine from the other rooms at the back of the house.

Outside these three concentric circles of houses with their ring roads, the site is divided up by straight roads (see Plan, page 279). The blocks of houses bordering on them are arranged, not in straight lines parallel to the roads, but in crescents, and the segmental spaces thus left between the houses and the roads are planted with trees and shrubs. This avoids the dull monotonous appearance of long straight rows of houses.

Sites are reserved for shops and for public buildings. The South Yorkshire Coal-field Church Extension Committee has already built good churches at Maltby and at Rossington, and the Colliery Company has provided vicarages for the clergymen. At Maltby there is a large Workmen's Institute, built at a cost of about £5000. This contains a public hall, where concerts and other entertainments are held, a billiard-room, a central lounge with a bar for refreshment, and several smaller rooms for reading and games and for committee meetings, also accommodation for the caretaker and his wife. In connection with it are a bowling green, and a field for cricket and football. It is managed by a committee of the workmen, with a supervising control on behalf of the colliery owners.

The members' subscription is 1s. a quarter year.

Another popular institution is a Cinema Picture House provided by private enterprise.

The whole of the capital required for the making of these villages has been provided by private investors.

The houses as soon as built, or sometimes before completion, have been sold, generally in blocks of four, at prices ranging about £185 to £195 per house inclusive of land, under an agreement by which the colliery company agree to pay to the purchaser a fixed rent per house each quarter year, amounting to 6 per cent on his money paid, and to keep the houses in repair, and to pay all rates and taxes except landlord's property tax, for a period of forty years.

The total cost, at prices prevailing before the war, of providing a village of about 800 houses such as that designed at Rossington cannot be put at less than about £160,000, and to do it for this sum, capable management and strict attention to economy are required.

EDLINGTON

The Yorkshire Main Colliery Limited are laying out a village in the neighbourhood of their large new colliery at Edlington near Doncaster.

The scheme provides for a total of 1200 houses, of which about 800 had been built in 1917.

There are several different types of houses, which are let to the miners at weekly rents of 5s. 6d., 6s. 9d., 7s. 6d., and 8s. 6d., free in all cases of rates and taxes.

Water and gas are laid on to every house. A separate stop-tap for the water is provided for each house, a wise provision which should be made always.

The 5s. 6d. cottage has three rooms, two bedrooms upstairs, and on the ground-floor a kitchen living-room, with scullery and pantry and the usual offices in a yard behind.

The 8s. 6d. house provides five rooms and a bathroom.

Some of them have been built with the aid of a local Building Society, and by paying an extra 2s. a week the occupiers may become owners of the house in a period of about ten years.

Most of the houses so far have been built by the Yorkshire Land and Development Company, who began operations here in 1911 when the shafts were being sunk, but latterly the colliery owners have taken the building of the village into their own hands, and have already completed 200 houses.

A good type of house which is let at a weekly rent of 7s. 6d. is distinguished by a high-sloped roof which allows of a good-sized attic room in addition to the three bedrooms on the story below. This attic is lighted by three fan-lights in the roof, two of which are made to open. These houses are provided with a bath in the scullery, having a table-top as previously described.

The contract price for building at pre-war figures was £190.

The houses are built in blocks of six generally, some of four, and are arranged in crescents of various curves, and some in straight roads.

Attention may be called to one or two devices which have been adopted for relieving the monotony of long rows of similar houses.

In one long straight road lined by houses at each side, the blocks are set in-and-out, each alternate block being set back a few feet behind the front line of the two adjacent blocks.

And in some of the crescents where the houses are faced with rough-cast or pebble-dash, the appearance is relieved by varying the extent of front covered in adjacent blocks—one block being coated down to the damp course, and the next only the upper story.

Garden ground is provided to many of the houses, but when the writer visited the village in the autumn of 1917, few of the gardens were being cultivated. The war had taken about 1000 of the younger men, and besides had caused a considerable shifting of the population. The proper cultivation of gardens requires a settled population.

BOLSOVER

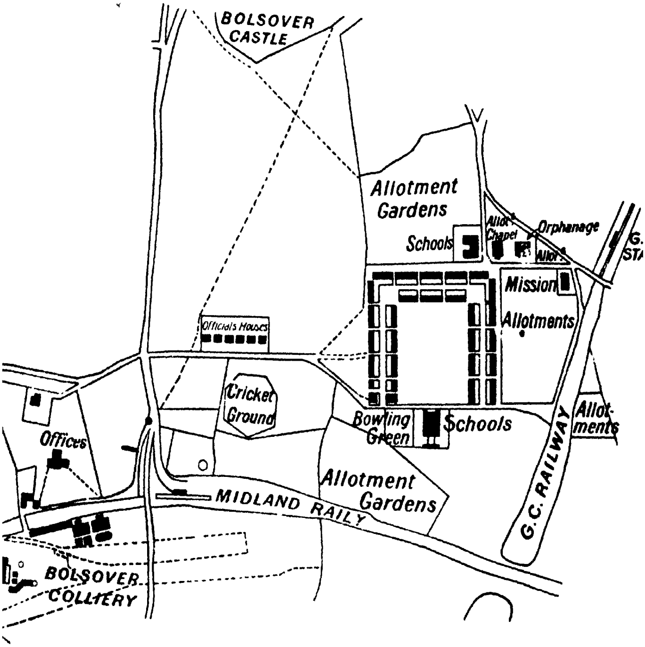
There are few, if any, pleasanter or cleaner or better kept colliery villages than Bolsover in Derbyshire. It is not new, having already been in existence for more than a quarter of a century. The model village known as New Bolsover, to distinguish it from the old village of Bolsover, was built some twenty-five years ago, when the colliery was started, and comprises 220 houses. Now houses extend all the way up the hill to Old Bolsover, where Bolsover Castle, in the commanding position in which it stands, forms the dominating feature of the landscape.

The castle is not now occupied, but the Duke of Portland allows its extensive grounds to be used for public purposes, such as flower shows and ambulance brigade inspections, so that it makes a valuable addition to the amenities of the village.

Lay-out

In its general lay-out (see Plan, page 285) New Bolsover reminds one rather of a college quadrangle surrounded by its buildings, except that in this case the buildings are miners' cottages, and one of the four sides of the quadrangle is left open. The central rectangular space covers 5 acres, and consists of grass with paths bordered by trees and belts of shrubs, all kept in good order. Round it on three sides are the houses, built in blocks of eight.

There are two rows of them, the inner row looking on to the central space, and the outer facing the other way towards the open country, so that all of them have a pleasant outlook. The creepers growing over many of the houses add to the attractive appearance.



Bolsover.

Between the backs of the rows of houses is a space of 100 feet. The yards at the back occupy 33 feet each, leaving 34 feet for a road. Down the centre of this road a tramway is laid for bringing coal to the houses. Each tenant is allowed 1 ton a month gratis, and this is brought in trams and deposited on the road, opposite the back entrance to the house, whence the occupier can readily shovel it into his coal-house. The road and the house yards are laid with good asphalt, which is kept clean.

Houses

The houses, which, it should be remembered, were built more than twenty years ago, have a 15 feet front and a 30 feet gable, the yard behind being 33 feet deep by 15 feet.

The accommodation of most of them is—on ground-floor—parlour in front, kitchen and pantry behind, with coal-house and earth-closet and covered ashpit in the yard; and upstairs three bedrooms, two of them having fireplaces.

Some houses have an attic story, containing one good-sized room, lighted by a dormer window, and in this case on the story below instead of the three rooms, as in the other houses, there are two larger rooms.

They are built of 9-in. brickwork, red bricks; roofs slated with Welsh slates. The rents run from 4s. 3d. to 5s. 6d. a week, averaging 4s. 9d., free of rates and taxes, which are paid by the owners, who also supply water and coal gratis.

In front of most of the houses is a little garden, and an allotment garden averaging about 400 sq. yds. in area is allowed to each tenant at a nominal charge of 4s. a year.

Twelve larger houses—semi-detached—are reserved for officials.

Institute

The village Institute is more comfortably furnished and better kept than workmen's institutes sometimes are. Besides the usual accommodation, namely, billiard-room, reading-room, smoke-room, games room, and committee room, it contains, what is not always found in these institutes, a library of 900 volumes, the average circulation being eighty books per week.

In a case affixed to one of the walls of one of the rooms are kept some handsome silver challenge cups and prizes won by Bolsover Colliery teams in cricket and other competitions.

The membership of the Institute numbers 400 to 500; the subscription is 1s. a quarter year, and the management is in the hands of a committee of ten elected by the members, with the general manager of the colliery as chairman.

As is usual with these colliery Institutes, the members pay[1] a yearly rent for it to the colliery company, and the members' subscriptions and all money taken for refreshments, billiards, etc., goes to pay the rent and the upkeep, any surplus being devoted to objects ministering to the benefit of the village community.

With a membership of four to five hundred, there is no financial difficulty, and these Institutes are generally self-supporting.

Near the Institute is a full-sized bowling green, surrounded by flower borders, also skittles and quoit grounds, and not far off is the cricket ground with a good pavilion, and also a miniature rifle range.

The schools, which were built by the colliery owners some twenty-five years ago, are remarkable for a very spacious central hall—such as is seldom found in a village school—round which and opening into it are the various classrooms. It was designed to serve not only the purposes of the school, but also to be used for public meetings and entertainments.

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[1] In some instances no rent is paid to the colliery owners, who provide the Institute, and hand it over on certain conditions. For example, at a Colliery Workmen's Institute in Co. Durham, the conditions are as follows:—

The owners entrust the management of the Institute to a Committee of sixteen members of the Institute and six trustees; such Committee to have complete control of the management of the Institute.

The sixteen members of the Committee to be elected annually at the General Meeting in January. The six trustees to be nominated by the owners, and to be ex-officio members of the Institute and Committee.

The donors or their agent may resume possession of the Institute on giving the Committee three months' notice.

The donors or their agent shall have power to veto any game, rule, or practice that may seem to them inadvisable, but before any veto be put in force, the Committee may meet the donors or their agent to state their views and discuss the point in question.

The Committee shall maintain and leave the buildings and premises in good order and repair.

Another village institution which deserves mention is known as the Orphanage. It was built by the late Mr. Emerson Bainbridge, who was the initiator and first chairman of the Bolsover Colliery Company, for orphan boys brought from the London slums, many of whom subsequently earned their livelihood by working at the colliery.

It is an attractive building both inside and out, containing a variety of rooms, including a gymnasium and bathrooms, and is in charge of a resident matron.

It is not now used as an orphanage, but serves a useful purpose as the centre of various village organizations, such as the St. John's Ambulance Nursing Association, the Baby Welfare movement, and at present it is the headquarters of a local corps of National Volunteers, 450 strong, "the Home Guards," which was formed amongst the colliery workmen early in 1915.

Near to the Orphanage is a handsome Wesleyan Chapel, and a Mission Church connected with the Parish Church at Old Bolsover.

The Bolsover Colliery Co. Ltd., under the guidance of its managing director, Mr. J. P. Houfton, is noted for its generous treatment of its workmen.

CRESWELL COLLIERY

The second undertaking of this company after Bolsover was Creswell Colliery, which lies some six miles to the north-east of Bolsover. It is a large colliery employing more than 2000 men and boys. The model village here is laid out on similar lines to that at Bolsover, but on a larger scale. The central open space of grass land, which, amongst its other advantages, is such a boon to the children, is roughly elliptical in shape, and is entirely encircled by a double row of houses, built in blocks of four, six, and eight.

The prevailing type of house has five rooms—kitchen and parlour on ground-floor; three bedrooms upstairs, two with fireplaces, and a scullery and the usual outhouses in the yard behind.

These houses are let for 6s. a week, free of rates and taxes, and water and coal are provided gratis by the owners.

Many of the houses are lighted by electricity, which is supplied by the owners at a charge of 1s. a week, or 3½d. per unit, at the option of the tenant. The latter seems to be the more economical arrangement.

A larger type of house containing a parlour with a bow-window, a kitchen, and a kitchen-scullery, and upstairs three bedrooms and a bathroom, is let for 8s. 6d. a week free of rates and taxes. The whole village comprises about 1000 houses, many of which have been built by the miners themselves, or by private enterprise, and sold or let to men working at the colliery.

MANSFIELD COLLIERY

Another large colliery belonging to the same company is situated about two miles to the north-east of the town of Mansfield in Notts.

Mansfield Colliery began drawing coal in 1907, and is famous for the efficiency of its "winding" equipment. From a depth of 543 yards, it was producing, before the war, from two winding shafts a normal output of 4500 tons daily within an eight hours' shift, which means 7 hours 40 minutes of actual coal winding.

At each wind six trams containing 15 cwt. each, or together 4 tons 10 cwt. of coal, are raised to the surface, and the winding and change of tubs are done within the minute.

The shafts are each 19 feet in diameter, the cages are double-decked, holding three trams on each deck, and the dead weight on the end of the rope when lifting from the bottom of the shaft is 20 tons.

The record wind from the two shafts is 4850 tons of coal in 7 hours 40 minutes.

FOREST TOWN

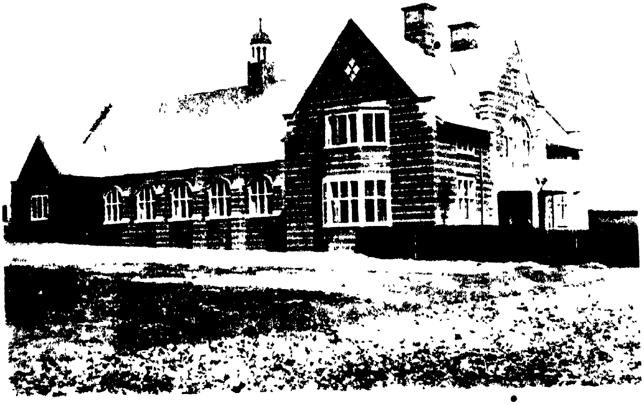
The owners have built a village of some 320 houses in the neighbourhood of the colliery, but most of the workmen employed, of whom there are more than 2000, live at Mansfield. This town has spread considerably in the direction of the colliery since it started, and many of the houses now occupied by miners have been built by private enterprise, and by the miners themselves. The village near the colliery, which is known as Forest Town, has the distinction of having been visited by their majesties, the King and Queen, during their tour through the Midland industrial districts in June 1912.

General Lay-out

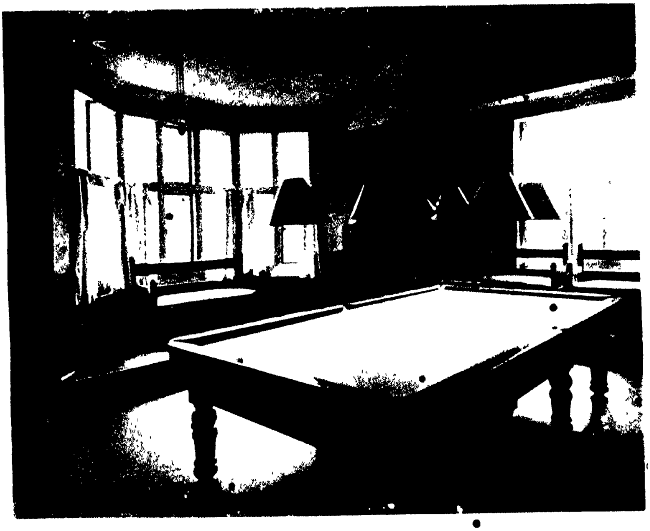
There is not much of particular novelty or interest in its general lay-out. The houses are built in parallel rows running at right angles to, and right and left of a central road 24 feet wide, with foot pavements o feet wide at each side. Each row consists of nine houses, and extends to a length of about 190 feet from each side of the central avenue.

The rows face each other with a space of 38 feet between, which is laid out in gardens—each house having garden ground about 17 feet long by 20 feet wide in front of it—leaving 4 feet for a paved footway between.

At the back there is a yard 24 feet deep, bordering on a road 12 feet wide, the space between the backs of the houses being thus 60 feet. The yards and the roads between are paved with bricks, the experience here being that a pavement of bricks is more durable than asphalt. No doubt a good deal depends on the quality of the asphalt.



DRILL HALL, FOREST TOWN



BILLIARD-ROOM, WORKMEN'S INSTITUTE, FOREST TOWN

A man is employed by the company solely on cleaning and scavenging work about this village of 320 houses.

Trees have been planted at short intervals along each side of the main central road; ivy and other creepers are growing over a good many of the house fronts; and when the gardens are well kept, the monotonous appearance of parallel rows of houses is relieved by a good deal of colour and green leaf.

Houses

As to the houses, they have a 21 feet front by 26 feet gable, covering a floor area of 546 square feet. On the ground-floor is a parlour, a kitchen, a pantry and a large scullery containing a "copper" for washing clothes. Upstairs there are three bedrooms, two of them having fireplaces, and the third, a tiny room, generally used for keeping boxes, etc.

In the yard behind is a coal-house, and an earth-closet with a covered ashpit.

The contract price for these houses built some time before the war was £175.

They are let to the miners at a rent of 6s. a week, free of rates and taxes, and the owners supply coal and water gratis.

Institute

The prominent feature of the village is the handsome Workmen's Institute, with its extensive and well-laid-out and well-kept grounds. These include a cricket ground and pavilion, a full-sized bowling green with five rinks, and two lawn-tennis courts. Encircling the cricket ground is a properly laid track for cycling or running, ¼ mile in length, giving four laps to the mile.

Interspersed throughout are flower-beds and borders, with shrubs and trees, and a gardener is kept regularly employed.

Inside, besides the usual accommodation to be found in the best of such buildings, there is, what the writer has not seen elsewhere, a covered-in skittles alley! This affords recreation when the weather is bad.

Besides this Institute the owners have provided a fine Drill Hall, which is used by the Lads' Brigade, the St. John's Ambulance Brigade, the local corps of National Volunteers, and for dances and entertainments.

A handsome church has been built, with a vicarage; large schools with extensive playground attached; and a Wesleyan Chapel.

PENGAM HOUSING SCHEME

In South Wales one of the most useful agencies for dealing with the housing of the miners is Messrs. Welsh Garden Cities Limited, Dumfries Place, Cardiff, which was formed about 1910.

Through their agency, and under their direction, several housing societies have been formed, and have been the means of erecting upwards of 2000 houses in the thickly populated colliery districts.

Perhaps the best example is the Pengam Garden Village, now nearing completion.

The site chosen for this scheme is near the Powell-Duffryn Coal Company's Britannia Colliery, in the centre of the Rhymney Valley, about 15 miles from Cardiff.

The site is an elevated piece of ground, the level of which is about 800 feet above sea-level. The chief difficulty architects and builders have to contend with in South Wales is the narrowness of the valleys and the steep slope of the mountain sides, and only here and there is it possible to have anything in the nature of an open site for the purposes of any large housing scheme.

The Pengam site is one of the exceptions. It is conveniently situated near to several railway stations, and to all intents and purposes is level.

COPARTNERSHIP BUILDING SOCIETIES

To carry out the scheme, Messrs. Welsh Garden Cities Limited formed the Pengam Housing Society Limited, registered pursuant to the Industrial and Provident Societies Act, 1903.

This society was formed in 1912, with a managing committee, of which Mr. E. M. Hann, General Manager of the Powell-Duffryn Steam Coal Company, is chairman.

The society is a copartnership one, in which the tenants are invited to become shareholders, and get 5 per cent interest on any money invested.

In addition, a scheme has been outlined whereby the tenant can become the owner of the house he lives in, the system adopted being as follows:—

The tenant takes shares in the society until his shares reach the maximum allowed—£200. Afterwards, he is allowed to take up 5 per cent loan stock in the society until he has invested a sum in shares and loan stock equal to the value of the house he wishes to purchase, and when that time arrives his shares and loan stock certificates are cancelled, and he is handed the house free of all further liability.

Working men as a rule will not put their money into these societies until there is some visible embodiment in houses built, but every encouragement is offered to men to become interested in the society, and ultimately become the owners of their own houses.

The total cost of the Pengam Garden Village of about 500 houses is £112,000.

A loan of about £75,000 has been obtained from the Public Works Loan Board at 3¾ per cent interest, plus a small charge to cover the repayment of the principal, spread over forty years.

The ground is held on a 999 years' lease, at a yearly ground rent of about 34s. per house. This covers the cost of roads, sewers, and development charges.

Altogether, the society has erected about 500 houses, which are occupied mainly by the workmen of the Powell-Duffryn Steam Coal Company Limited.

The lay-out of the scheme provides for a large open space in the centre, from which the main roads lead. Around the central open space, shops have been built, and the Monmouthshire County Council have already erected a large school, and a site is reserved for other public buildings, all grouped together in the centre.

Some general features of the village are as follows :—

All the houses are semi-detached. They are set back from the pavement line from 15 to 20 feet, leaving a garden space in front averaging about 300 square feet.

Large garden space is provided at the back of each house, and ground is available near to the village for allotments, etc., the charge for allotments being about 6d. a perch.

For dividing off gardens, iron palisading is in general use in preference to walls. It has the advantage of allowing freer access to light and sunshine and air.

Every encouragement is given to the tenants to cultivate their gardens. The first annual Flower Show was held in the village in August 1916, at which there were no fewer than 700 exhibits.

The houses are all provided with baths, having hot and cold water services.

Each house contains a large kitchen-living-room, and at least three bedrooms, and the majority of the houses have a parlour and a scullery in addition.

Ashes and refuse are cleared away every morning by the carts of the local Sanitary Authority.

The houses are all of neat design, built of brick, some of them having a brick elevation, others covered with rough-cast, the roofs being slated with Welsh slates.

The village is lighted by gas, the mains being laid in every house.

There is in addition a good water supply.

The houses are built to varying designs, but chiefly following four classes, let at weekly rentals of 6s. 6d., 7s. 6d., 8s., and 8s. 6d. per week, the rateable value being from £8. 10s. to £10. Rates and taxes are paid by the Housing Society.

Tenants are allowed to purchase the houses at cost price, the cheapest being about £210, rising to £285 for the best class house.

In addition to Pengam, Messrs. Welsh Garden Cities Limited have been responsible for several other attempts to deal in a practical way with the housing question in South Wales.

Lower down the Rhymney Valley, at Hengoed, a similar scheme of 1000 houses was started just before the war. This is founded on the same basis as the Pengam scheme, and when complete will cost about £250,000.

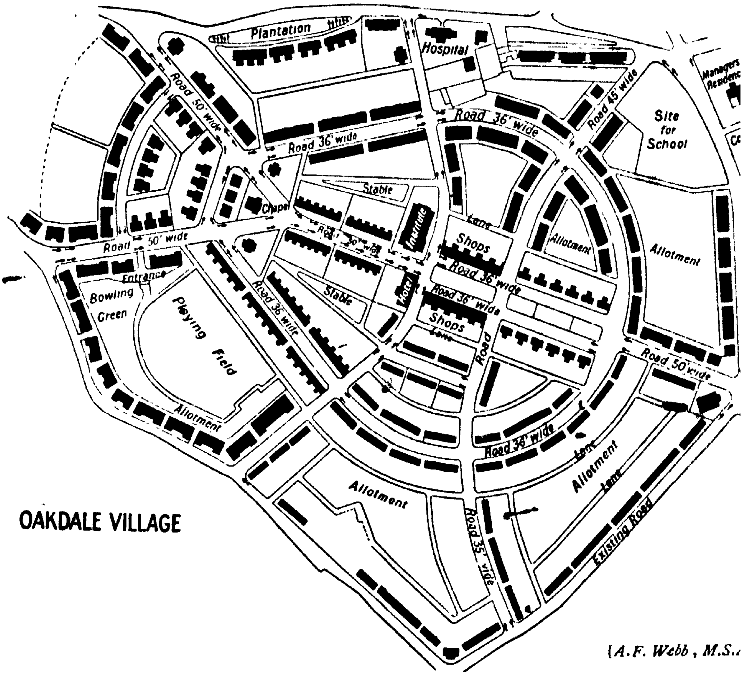
Another scheme is to accommodate workers employed by the Powell-Duffryn Coal Company in the Aberaman Valley. This scheme is for 264 houses, and when complete will cost about £60,000.

Another scheme they have in hand is at Gilfach Goch. In this case the houses are for the South Wales Copartnership Housing Society, of which the late Lord Rhondda was chairman, before he went to the Local Government Board. The scheme is for 500 houses, which are mainly occupied by men employed in the mines of the Cambrian Coal Combine.

OAKDALE COLLIERY

The Oakdale Colliery Village of the Oakdale Navigation Collieries Limited (an offshoot of the Tredegar Iron & Coal Company Limited), in the Sirhowy Valley, Monmouthshire, is a model village especially distinguished by the thoroughly substantial character of all its buildings. It has been built directly by the colliery company to the design of their capable architect, Mr. A. F. Webb, and no expense has been spared. The site is a healthy one on high ground 600 feet above the sea-level, and commands extensive views over the attractive country in the neighbourhood.

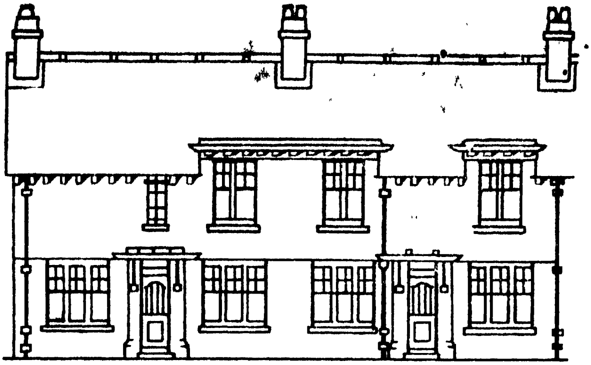
It is divided up symmetrically into about a dozen building lots by roads as shown on the block plan (see Plan). The central portion is outlined in the shape of a pear, roughly conformable to the shape of the site,



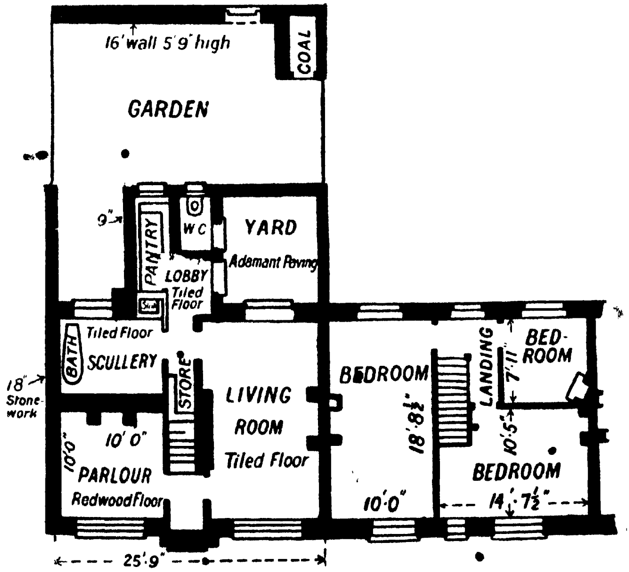
OAKDALE VILLAGE

[A.F. Webb, M.S.

by the ring road surrounding it. Right through the centre of the site is a straight road 50 feet wide which forms a continuation of the main road leading to the village, and at its other end branches into two roads. Roughly at right angles to the central road are two other roads laid out on curving lines and crossing the site from east to west.



FRONT ELEVATION



GROUND FLOOR PLAN-BEDROOM FLOOR PLAN

Plan of Houses, Oakdale Village.

[*A. F. Webb, M.S.A.*

The roads and pavements are thoroughly well made, and grass margins have been inserted in many of the pavements.

It will take some time yet to complete the full scheme of the village as originally designed.

In October 1916, when the writer saw it, some 400 houses had been built, disposed over an area of about 40 acres, making ten houses to the acre, and housing a population not far short of 3000.

The complete scheme comprises the building of 700 houses.

Brick is the material used; generally a contrast of colour is shown by the lower story being finished in dark red brick and the upper in rough-cast, a common brick being used underneath. Some of the houses are semi-detached, but most in blocks of four or six.

The outside walls are cavity walls consisting of two 4½ in. walls with an air space of 2 in. to 3 in. between.

Every house is provided with a bath with hot and cold water laid on. In many of the houses the bath is in the scullery, but in the larger houses it is in a separate little room partitioned off from the scullery, which is a much better arrangement. For miners coming into the houses in their dirty clothes, a bath on the ground-floor is perhaps more convenient than upstairs.

One of the best types of house is that shown on Plan, page 297. It has on the ground-floor a living-room extending the whole distance from front to back of the house, with windows in both outside walls, making a well-lighted and well-ventilated apartment; on the same floor are a parlour and a kitchen-scullery, with pantry and bathroom. At the back of the houses is a paved yard. This yard borders a garden at the back without any wall or fence between them. Many of the houses have also some garden ground at the front. On the upper floor there are three or four bedrooms. This house covers a ground area of about 500 square feet, and in 1915 cost about £350 to build. It is let at a rent of 9s. a week, inclusive of rates and taxes, which amount to about 2s. 6d. Most of the houses are lighted by gas, which costs 4s. 9d. per 1000 cubic feet.

A smaller class of house let at a rent of 5s. 6d. a week plus 2s. for rates and taxes, making 7s. 6d. a week, contains on the ground-floor a parlour and kitchen and bathroom, and the usual outhouses in a paved yard at the back, and upstairs three bedrooms.

Another type of house, semi-detached, with a separate bathroom, a verandah at the entrance, and garden ground both in front and behind, is let at a rent of 10s. 3d. a week, inclusive of rates and taxes.

The tenants have the opportunity of buying these houses on a sixteen years' purchase system by depositing sums as they are able, until the whole price has been paid, 5 per cent interest being charged on the outstanding balance during this period.

A portion of the site is laid out in allotments about 300 square yards in area, which are let to the tenants of the houses for growing vegetables at a rent of 5s. per year. All rents are kept off the weekly wages at the colliery office.

All the streets are planted with trees.

The village community has been enterprising and progressive in providing various public institutions, mainly on the initiative and by the subscriptions of the miners themselves. These already include a hospital with sixteen beds for accident cases—infectious cases are not admitted—built at a cost of about £6000; three chapels and an hotel; and a Workmen's Institute now nearing completion.

These buildings are tastefully and ornamentally designed, and reflect credit on the architect. The Workmen's Institute, which stands at the centre of the village, is a particularly complete building of its kind, costing over £6000, and with its fine front of local Pennant stone with Portland stone it will present a handsome appearance when finished.

It contains on the ground-floor a large entrance hall, a newspaper and magazine room, another reading-room for books, a lending library, a refreshment room, and a large billiard-room to hold six tables. Upstairs is a lecture or concert hall to accommodate 350 persons.

A gymnasium and a swimming bath are in contemplation, and a large cinema hall.

BUILDING CLUBS

In South Wales many miners' houses have been provided by the agency of Building Clubs.

The object of these Clubs is the raising of funds by the subscriptions of their members to enable them to build houses.

To take an actual instance—the subscription is 20s. per lunar month.

By way of enforcing the regular payment of subscriptions, the rule is that a member who fails to pay his subscription is liable, when it is three months in arrear, to be fined 1s. in the £ per lunar month on the amount in arrears, and if he continues to neglect payment for twelve months, he ceases to be a member and forfeits all his interest in the Club, but continues liable for all monies due from him to the Club, together with 5 per cent interest.

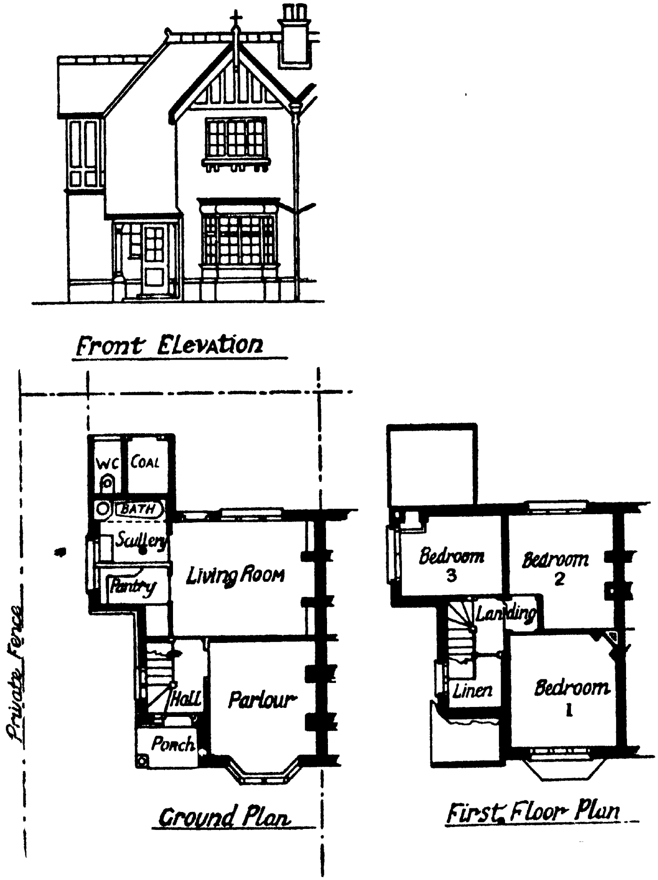
Each member on joining the Club signs the following agreement:

"Each of us, the undersigned, hereby agrees with the others and each and every of them to become a member of Building Club, and to be bound by and comply with the Rules of the Club as before set forth."

No member can withdraw from the Club without the consent of the Club.

In the event of the death of a member, his share and interest shall belong to his personal representative.

The rules provide for the appointment of the following officers: Two Trustees, Banker, Architect, Treasurer, and



Scale 8 feet to 1 inch

Building Club Houses, South Wales.

[Frank B. Smith, C.E.

Secretary, and of a Committee consisting of not less than five nor more than nine members, exclusive of the officers.

Five constitutes a quorum at the meetings. The Club may borrow such sums of money as may be required for the purposes of the Club, and "for securing the repayment thereof, it shall be lawful for the Trustees, and they are hereby authorized to execute or direct to be executed or given any and every such form of assurance or mortgage of the property and assets of the Club, and either with or without an express or implied power of sale, and such other powers, conditions, and provisions as they in their discretion may deem proper and necessary."

The houses, as soon as convenient after the building contract has been given out, are allotted by ballot amongst the members, and if a member wishes to make any addition or alteration to the premises allotted to him beyond the general contract, he makes his own terms with the contractor for any such extra work, subject to the approval of the Committee.

If a member does not occupy a house allotted to him, it is let or leased by the Club, who then become responsible for the rent and for tenants' damages.

As far as it is practicable, members are encouraged to live in their own houses, as they then take more interest in maintaining them in good order, and there is found to be a considerable saving in the cost of repairs, as compared with an occupation by a tenant who is not financially interested in the Club.

The Club may be dissolved at any time by the consent of three-fourths of the members.

A Club constituted on this basis, comprising thirty members, most of whom are miners employed at the same colliery, built shortly before the war thirty houses, semi-detached, and laid out on the garden village plan.

As shown in Plan, page 301, they are five-roomed houses with a bathroom and the usual offices, built of brick finished on the outside with "pebble dash," and having gardens both in front and behind, each garden being about 900 square feet in area.

They cost on the average £236 a house, and are rented at 6s. 6d. a week, which covers rates and taxes and water supply. They are lighted by gas, for which the tenant pays.

The total cost of these thirty houses, amounting to about £7000, was advanced by a bank, on the personal guarantee of the members of the Club and a few outside gentlemen.

The repayment of this loan is met by a contribution of 3s. 9d. a week per house.

The rent of 6s. 6d. a week is more than sufficient to meet expenses, and the surplus is applied to a further reduction of the loan.

Under the scheme of repayment the loan will be cleared in about sixteen to seventeen years.

In the majority of the Welsh Miners' Building Clubs, the weekly repayment is at the rate of 5s. a week. Though this sum in addition to the weekly rent may be a heavy call on the miner for a time, yet there is a distinct advantage in the higher rate in his sooner possession of the property.

The method of loan and repayment is similar to that of the building schemes of the Co-operative Societies in the North of England, but the bank lends the money on receiving satisfactory security in place of the Co-operative Society on its own initiative.

Evidently the success of Building Clubs must depend upon the members and especially upon the officers. If they are dishonest or incapable and the houses built are unsatisfactory and insanitary, the club system becomes discredited.

Many good houses have been provided by well-managed building clubs, but latterly this method seems to have been superseded to a large extent by other agencies.

The membership of Building Societies in Wales was 36,000 in 1896, and had fallen to 15,055 in 1914.

KIRKCONNEL HOUSING SCHEME

Scotsmen are famous for getting good value for their money, and this useful characteristic may be traced in their housing accommodation. Miners' houses are built at a cost which allows them to be let at lower rents than are paid in most of the English and Welsh mining districts.

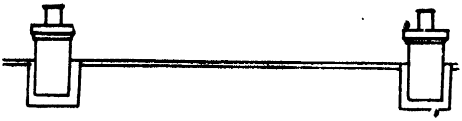
At Kirkconnel Colliery, in Dumfriesshire, there is a clean healthy village of recent construction and still in process of extension. It is pleasantly situated on the banks of the river Nith, and has the advantage, like many other pit villages, of being in the open country with plenty of fresh air and healthy surroundings. This advantage accounts, no doubt, to a large extent, for the exceptional healthiness of the coal-mining population.

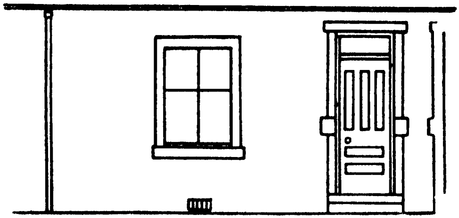
The type of cottage now being built at Kirkconnel is shown on Plan, page 305. Brick is the principal building material, some of the cottages being built with the common red bricks and cement rough-cast, and others with terra-cotta facing bricks cement pointed.

The single story cottages are in 9-inch solid brickwork, and the two-story cottages in 14-inch solid brick. No cavity or hollow walls are now used, the inner walls being "strapped" and "lathed." All have gardens at the back and small garden plots in front, opening on to a 6-foot paved path and a 24-foot macadam surface road. There is a space of 60 feet between the faces of the houses. An adequate supply of water and gas is laid on to each house, and special attention has been paid to the drainage and sanitary arrangements.

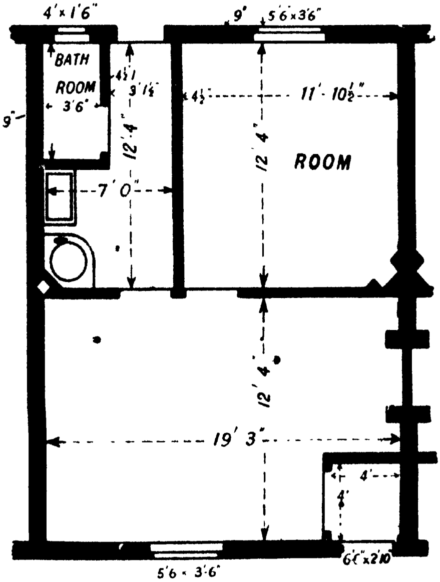
The internal arrangement of the cottage is as follows:—

One enters by the front door into a small vestibule provided with hooks for hanging coats, and by a side door off it into the kitchen-living-room. Along the wall opposite is a recess containing two beds set end to end with a brick partition between, a modern development of the arrangement common in the old Scotch "biggin'," as it may be seen in the cottage at Alloway where the poet Burns was





FRONT ELEVATION



SECTIONAL PLAN

Plan of Houses, Kirkconnel.

born. This recess is the full height of the room (9 feet), and can be shut off from the rest of the room by drawing a curtain across it. In the corner near the fireplace is a cupboard provided with shelves. A door from the kitchen leads into a passage to the back door over which there is a window opening on hinges. At the side of this passage is a bathroom with a good-sized bath and hot and cold water, and an up-to-date water-closet fixed alongside the bath. The sink and washing boiler are provided in the scullery. A feature of the washing boiler is a special apparatus for heating an unlimited quantity of water for baths or other purposes. The sitting or bed room is 12 feet square, is entered from the kitchen, and has a large window and a good fireplace. The one-storied houses of this stamp are let for 3s. 8d. per week, free of rates. They cost for building alone, without the land, £100 each, at prices prevailing before the war. A considerable proportion of the houses are built higher to allow of an upstairs room, which is usually about 18 feet by 12 feet in area, and is reached by a staircase from the front vestibule. This upstairs room is lighted and ventilated by a large dormer window projecting from the roof. These cottages cost £145 each to build before the war, and the rent paid for them is 4s. 6d. per week free of rates. There are no ashpits in the district, all ashes and refuse being placed in bins and removed by carts three times each week.

In this colliery village there is also a lodging-house for single men, with accommodation for fifty-five of them. The sleeping apartments contain ten beds, and there is a large common room for meals. The men provide and cook their own food, cooking facilities being given them, and they pay 6d. per night for sleeping accommodation. The establishment is in charge of a man and his wife residing on the premises. This method of housing unattached men is not unusual at Scotch collieries, but is seldom found, so far as the writer knows, on the south side of the border.

In most colliery villages there is no provision for housing young unmarried men, except as lodgers. This leads to overcrowding and to other evils. A well-managed hostel or club-house is a useful provision for single men.

The village has been provided by Messrs. The Sanquhar & Kirkconnel Collieries Limited, with a well-laid-out bowling green and pavilion, which is greatly appreciated by the workers, who are enthusiastic bowlers.

A very fine "Institute" is now being completed, also at the cost of the colliery company. It contains a billiard-room with two full-size tables, a large reading-room, carpet bowling room, lending library, refreshment bar, caretaker's rooms, and the usual offices. It will be managed by a committee of the workers, and all in the district are eligible for membership.

Plans have been prepared for a large concert and cinema hall, which will be erected at the earliest opportunity.

In all from three to four hundred cottages have been erected during the last five years, and it is estimated that a further two hundred will be required to cope with the additional developments of the collieries at the end of the war. Apropos of the war, it may be mentioned that the village of Kirkconnel gave 33 per cent of its manhood, a fine achievement for a small mining village.

NEWDYKES VILLAGE

In connection with their Auchincruive Colliery at Newdykes, near Prestwick in Ayrshire, Messrs. William Baird & Company Limited are making a new village which has some noteworthy features. The war has delayed developments, but so far 184 houses have been built in three rows, leaving ample ground between them for gardens

A centrally situated building contains a laundry fitted with modern appliances and hot-air drying chambers, and a plentiful supply of hot water. Here the women from the surrounding houses do their washing at an average charge of 2d. an hour—3d. for the first hour, and 1d. an hour afterwards.

Adjoining the laundry is a small bathing establishment containing about a dozen shower-jets in separate compartments and a couple of ordinary baths, which can be used by the miners on a payment of 2d. a bath, including soap.

In the same building is a comfortable and well-lighted billiard and reading room.

There are two sizes of dwelling-house provided. They are all arranged on the "flat" system, the upper flat or story being occupied by a separate family from the lower, and being reached by an outside staircase.

The larger size contains a living-room fitted with a kitchen range, and two other rooms. Along the whole of one side of the kitchen-living-room is a recess of the full height of the room, fitted with two beds placed end to end in separate compartments, with a brick partition between, as already described (see page 304).

The scullery contains a gas cooker, so that in warm weather the kitchen fire need not be lighted.

Gas is laid on to every house, and is used for lighting as well as cooking.

There is also a good-sized pantry.

Besides this kitchen-living-room there are, on the same floor, two other rooms both having fireplaces. In one of them is a roomy cupboard fitted with shelves.

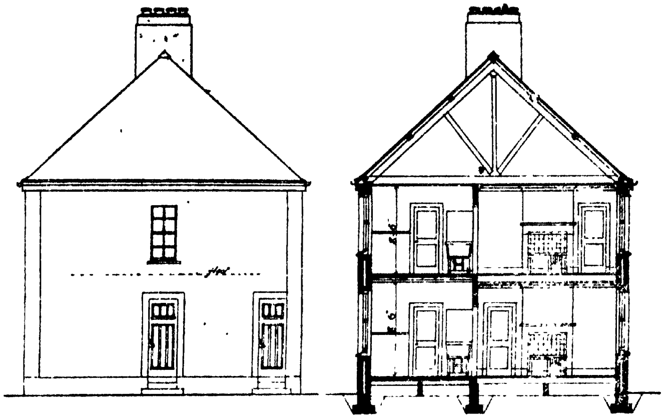
The upper story above contains exactly similar rooms.

Access to the upper story is by an outside staircase, made of stone steps and protected by an iron railing. Otherwise there is no communication between the upper and lower flat.

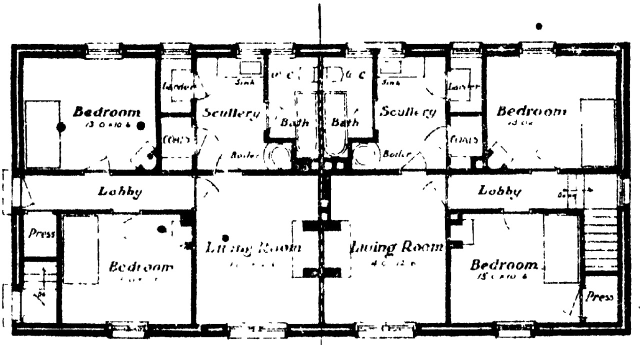
The upstairs houses have the advantage of a balcony, which can be used for sitting out in the open air.

This arrangement of houses in flats has its drawbacks, but it allows of considerable economy of space and construction.

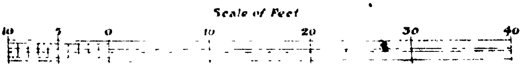
The scullery and pantry and a coal-house and water-



·Side · Elevation · ·Section ·



· Ground · Floor · Plan · · Upper · Floor · Plan ·



Double-flatted House with staircase inside.

(Mr. John Wilson's Special Report, Royal Commission on Housing in Scotland, 1917.)

(*Reproduced by permission of H M Stationery Office.*)

closet are in portions of the building which project from the main structure and allow of windows for light and air at either side.

The rent charged for these houses is 5s. 6d. a week.

There is a smaller double-flatted house, of a similar general design, but having only one room besides the kitchen-living-room, the rent of which is 4s. a week.

A personal inspection of these houses on a very hot afternoon in July convinced the writer of their sound sanitary condition. No bad smells inside or out, no open ashpits or deposits of rubbish, no dust or dirt, well-paved road and footways.

Inside, the rooms were well lighted and well ventilated. The inmates evidently appreciated their houses, and took a pride in keeping them clean and orderly.

Little flower-beds about 8 feet square let into the pavement between the projecting parts of the building were bright with flowers.

Double-flatted houses can be built at a lower cost than two-storied cottages, affording the same accommodation.

In his Special Report issued by the Royal Commission on Housing in Scotland (1917), Mr. John Wilson gives several designs of double-flatted houses, arranged in blocks of four. The Plan, page 309, shows one of these designs with the staircase to the upper flat contained inside the building, each flat being self-contained. The cost of building per house in brick, including drainage, water supply, fencing, footpaths, roadway, and sewer, at the normal rates prevailing at July 1914 in forty-seven different burghs and districts in Scotland, varied from £178. 10s., or 4·10d. per cubic foot at Glasgow, to £286, or 6·58d. per cubic foot in Argyll County.

"In every case the cost of a double-flatted house is cheaper than that of a cottage house of the same accommodation and practically the same superficial floor area. On an average the difference between the two rates is a little less than a penny per cubic foot"

"If the cost of the floor area of double-flatted and cottage houses be compared, it will be found that the cost of the former varies from 6½d. to 10d. per superficial foot less than that for the latter."

BATHING ESTABLISHMENTS

The healthiness and long life of the coal miner has been attributed to his having plenty of work, plenty of food, and plenty of washing.

The general provision of baths in the miners' houses which have been built in the United Kingdom during recent years seems to show that this arrangement for washing is preferred to the central bathing establishments at the pit-head which are common abroad in France and Belgium and Germany. (For a description of these bathing establishments, see "Miners' Baths," by H. F. Bulman and W. B. Wilson, *Trans. Inst. Mining Eng.*, 1912, vol. xliii.)

Undoubtedly a great source of dirt and of inconvenience and work for the women folk in miners' houses are the dirty and wet pit clothes of the male workers of the family when they wash at home. The writer has noticed more than once that, where a miner owns his house, he has erected at his own cost a serviceable wooden shed in the backyard, for washing and for keeping pit clothes.

The provision at the pit-head of bathing establishments where the miner can have a bath, change into clean clothes, leaving his pit clothes to be dried, and go home clean and comfortable would certainly tend to the cleanliness and comfort of his home. From the health point of view, also, this has much to recommend it.

Miners coming from their work in the pit are often in an overheated state, and in this condition their exposure to cold winds and rough weather on their way home may easily give rise to those bronchial troubles which are the chief ailment of the older miners.

The Coal Mines Act, 1911, Section 77, provides that "where a majority, ascertained by ballot of two-thirds of the workmen, employed in any mine . . . represent to the owner of the mine that they desire that accommodation and facilities for taking baths and drying clothes should be provided at the mine, and undertake to pay half the cost of the maintenance of the accommodation and facilities to be provided," the owner shall make the provision.

The sum contributed by each miner to the cost of maintenance must not exceed three halfpence per week.

But the British miner is essentially conservative in his own affairs, and as yet there has been very little response to this opportunity.

Since the Act of 1911 came into force, a few large and up-to-date pit-head baths have been erected.

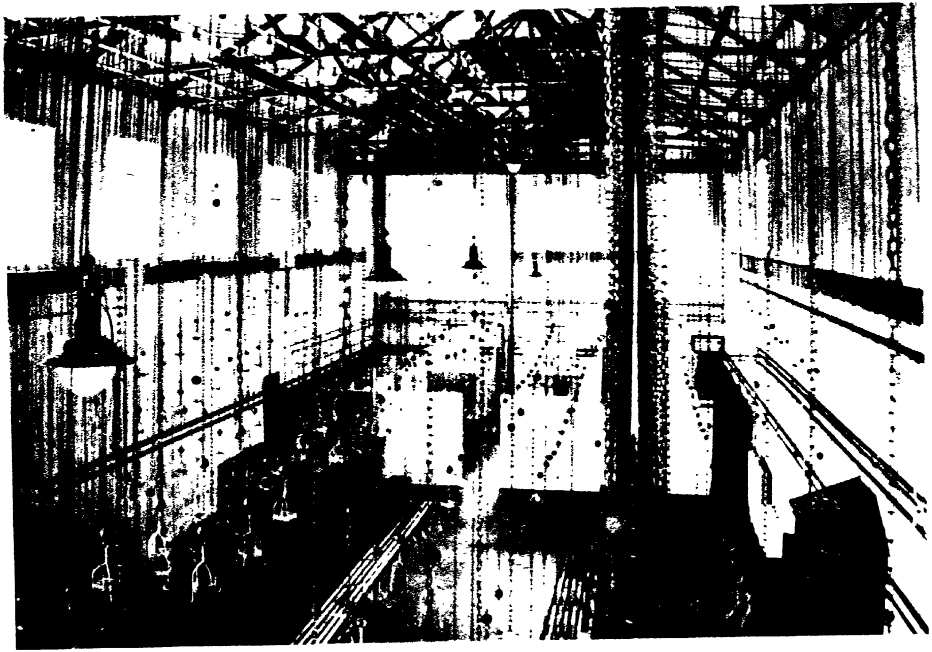
A notable example are those built in 1916 by the Ocean Coal Co. Ltd., at their Deep Navigation Colliery, Treharris, South Wales. The accompanying illustrations show the cubicles, each fitted with a shower spray jet, where the bather can thoroughly clean himself under a shower of hot water at a temperature of about 90° to 100° F. Having partially dressed in the cubicle, he comes out into the room outside, which is fitted with seats, and there completes his dressing.

Plate XV. shows the chains and hangers to which the pit clothes are attached. They are then drawn up to the top of the building, where they are exposed to a current of warm air, and thus dried and aired for the next day's work.

Accommodation has been provided for about 700 men, but as yet during the war only about 400 are using them. They are appreciated by a certain number of the men, and it is hoped that when the younger men, who volunteered at the beginning of the war, return to the colliery, the number using the baths will be increased.

Another large bathing establishment has been erected recently by the Wemyss Coal Co. Ltd., at their Wellesley Colliery, Fife, N.B.

It has been designed so that it can be extended if desired; at present it contains 84 cubicles and 332 clothes hooks. The dimensions of the building are 109 feet long



MINERS' BATHING ESTABLISHMENT, SOUTH WALES

by 38 feet wide and 10 feet to 14½ feet high. Each cubicle occupies a floor space of about 5 feet 6 inches by 3 feet 5 inches, and is fitted with a wooden seat hinged, and a clothes hook, besides the shower jet.

The cubicles are formed of galvanized cast-iron plates with suitable stanchions and ranged along the sides of the building, leaving a central space 27 feet wide for seats and clothes suspenders. Each chain is hooked to a numbered plate, by which each bundle of clothes can be readily identified by its owner.

The air enters through holes in the floor, which is about 30 feet above ground-level; is heated by passing between steam-pipe coils; and is drawn out at the roof through a system of air trunks by a fan. The suspended clothes are thus dried by the heated air drawn through them.

At present about 30 per cent of the men employed underground are using these baths. They pay nothing, but they provide their own towels and soap.

The cost of this bathing establishment at pre-war prices was about £1900. It is situated beneath the pit heapstead, the roof of the bathroom being the floor of the heapstead, which is constructed of reinforced concrete. The sides of the bathroom are formed of the steel supports of the heapstead filled in with brickwork.

At Wharncliffe Silkstone Colliery, Yorkshire, a bathing establishment was provided by the owners in 1902. It includes eight shower-baths and six slipper-baths. Out of 1603 persons employed at the colliery, only 72 use the baths. They pay 2s. per quarter year, and find soap and towels.

At four collieries in Lancashire baths have been built in 1913 and 1914. About half the workmen employed at these collieries are using the baths. They provide their own soap and towels, but contribute nothing to the expense.

At present the British miner in general still sticks to his old habit of washing himself in a small tub before the kitchen fire.

Even with a bath provided in the house, miners have been known to prefer a tub before the fire, and the [illegible] has been used for storing coals!

Personal habits of this kind, long continued, are not easily changed, but probably in time the advantages of pit-head bathing establishments will be more widely appreciated.

USEFUL POINTS IN THE DESIGN OF SMALL HOUSES

The following points which are worth noting as bearing on the best design of small houses, are extracted from the Special Report of Mr. John Wilson, Architectural Inspector of the Local Government Board of Scotland (Royal Commission on Housing in Scotland, 1917).

Living-room.—The minimum size desirable is 168 square feet of floor space, and the length should be a little more than the width, say 14 feet by 12 feet.

The fireplace should be in one of the walls at right angles to the window, and the doorway should not be on either side of the fireplace, because it interferes with the sitting space round it.

Larder should always have an outside window, with a wooden frame covered with fly gauze opening outside the window frame.

Lobby and Staircase.—Entrance lobby should give access to the staircase without entering the living-room.

Staircase should be not less than 3 feet wide, and be provided with a hand-rail on one side.

Bedrooms.—When there are only one or two, they should be not less than 125 square feet area of floor space. Where there is a third bedroom, it may be smaller, but should in no case have less than 500 cubic feet of space.

An oblong shape is more serviceable than a square as allowing more space for dressing purposes. The room should be so planned that the bed can be placed out of the draught from the window. A wall-press or cupboard for hanging clothes should be provided.

Structure.—Nine-inch solid brick walls should be

MINERS' BATHS, WELLESLEY COLLIERY, N.B.

strapped, lathed, and plastered on the inside, and rough-cast on the outside; otherwise they will not be found weatherproof in exposed situations.

Cavity walls should be of two 4½ in. walls with 3 in. space between, tied together with galvanized iron ties; the outside wall should be rough-cast or skimmed with cement on the outside face, and the inside plastered on the hard, not less than ½ in. thick. Care must be taken that no lime is left lying on the metal ties, and that the channel at the foot of the cavity is thoroughly cleaned out. The cavity must not on any account be ventilated, as the admission of air is liable to produce condensation on the face of the plaster on the inside wall.

The adherence of rough-cast depends a good deal on the quality of the brick.

A *Damp Proof Course* of slates and cement, stone slabs, or patent asphalt felt, should be laid over all the foundation walls about 4 in. above the finished level of the ground.

Slates.—Small-sized and thick slates are to be preferred to large-sized and thin slates. They should be laid with an average cover of 2 in. to 2½ in.

Floors of scullery, larder, coal-house, water-closet, and bathroom should be of concrete or impervious tiles. The latter are more costly.

Concrete should be laid on a bed of broken stones, blinded, and covered with a ½ in. coat of asphalt.

Wood floors are generally ⅞ in. boarded floors. Every precaution should be taken to guard against dry rot. All shavings and waste wood should be removed from underneath, and adequate cross ventilation underneath is essential. Ventilation gratings on one side of the house are not sufficient.

Joists should not be built solidly into the walls, and wall plates should always be placed above the damp proof course.

Windows.—Sash windows should be made to open top and bottom, and should be placed not more than 12 in.

from the ceiling, so as to allow of ventilating the upper part of the room.

Casement windows, if of wood, are not always satisfactory in exposed situations, and metal casements are too costly.

Cost.—The proportion of the total cost taken up by each of the trades engaged in building this class of house is given as follows:—

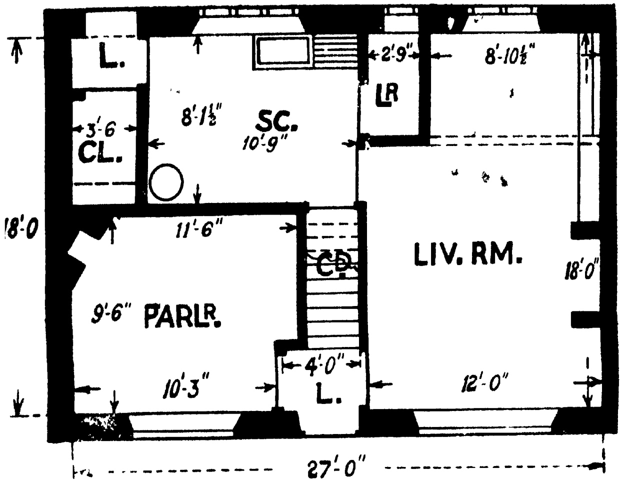
	Percentage of Whole Work.
Mason and brick work, including excavations, roads, sewer, and grates	40·2
Carpenter, joiner, and glazier	28·5
Slater and harler	7·4
Plumber	15·2
Plasterer	5·4
Painter	3·3
	100·0

The cost of building in Scotland has increased during the ten years 1904–14 a little over 20 per cent, which is due mainly to the rise in the cost of both raw and manufactured materials.

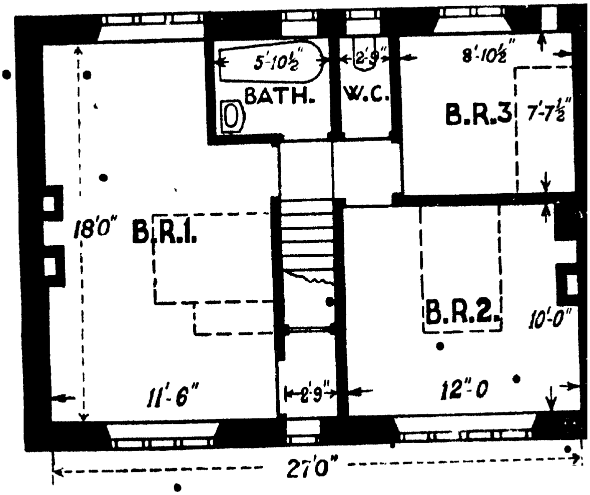
Since 1914—during the war—prices have, of course, risen much higher.

SUMMARY

The examples given show that a good many different agencies have been at work within recent years before the war in providing houses for miners. The colliery owners; the miners themselves, assisted by Co-operative Societies and Building Clubs; Public Utility Societies, such as Welsh Garden Cities Limited; Local Authorities; and private enterprise have all been employed. A considerable variety of house has been built, ranging from two-roomed cottages of the "but-and-ben" type, with a recessed compartment for beds, to two-storied houses containing five or six rooms and a bathroom. A good type (see Plan, page 317) is a two-storied house, having a frontage of 27 feet with a south aspect, and a depth of 18 feet, containing on the ground-floor



GROUND PLAN.



FIRST FLOOR.

Parlour House for south aspect.

a, parlour and a kitchen with a scullery and a pantry, and on the first floor three bedrooms, two larger ones provided with fireplaces and one smaller, and a bathroom and water-closet. The height of the rooms is 9 feet.

As regards the cost it varies a good deal in different localities, but on an average at pre-war prices it was about £200 for building, to which must be added £12 to £20 for cost of roads, sewers, fences, etc. For cost of building 4d. per cubic foot was something like an average figure.

For such a house the rent charged to miners is in many cases 6s. 6d. a week free of rates and taxes, and including water supply laid on to each house. Lighting is by gas or electricity for which the occupier pays a small charge.

When the future occupation of the houses and the rental to be received from them is practically assured, as it is usually in the case of colliery villages, the financial difficulty may be sometimes conveniently met by the colliery owners by selling or mortgaging the houses as soon as built to private investors, guaranteeing them a fixed rate of interest on their money over a considerable period of years, and undertaking to maintain the houses in good repair.

In mining districts where wages are high, and there is a steady demand for houses at good rents, private enterprise on the part of the miners themselves and of others has not been lacking to supply the demand, as may be gathered from the instances given.

Public Utility Companies are doing excellent work in some districts. There is plenty of room for the efforts of all these agencies, but in the best interests of the country it is to be hoped that private enterprise will be encouraged and not crushed out by State action.

As building contractors in the erection of large modern mining villages few firms have had a wider experience than Messrs. Hopkinson & Co. of Worksop.

The opinion of Mr. Frederick Hopkinson as given in the following extract from *The Times* of January 25, 1919, deserves attention :—

"The subject of the housing of the working classes is expected to be one of the earliest to be considered by the new Parliament. It has been estimated that a million dwellings will have to be built in order to satisfy the demand throughout the country. The position is greatly complicated by the enormous rise in the cost of material and labour. One firm, Messrs. Hopkinson & Co., of Worksop, who have been almost wholly engaged in the erection of model villages in connection with the largest colliery companies in South Yorkshire and South Wales, state that they used to build and sell a six-roomed house (freehold), including land and roads, for £188, and that the actual cost of building the same house at the present time, without land and other charges, is £420.

"Mr. Frederick Hopkinson, in conversation with a representative of *The Times* at the firm's London offices, 180 Piccadilly, speaking of the Government scheme of housing, said:

"'The proposal is that the local authorities should erect the houses with money borrowed from the Treasury at the present rate of interest. In seven years' time the houses are to be valued, and if any losses have been sustained, 75 per cent is to be defrayed by the Government and 25 per cent by the local authorities. To build, with labour and material so expensive as at present, would mean an enormous loss, and I maintain that the proper persons to stand the loss are not the ratepayers but the large industrial companies who will benefit by the erection of the houses. Before the war, the large industrial companies had through us solved the housing question so far as it affected their workpeople, without the need of Government assistance. Those companies are now fully alive to the necessity of providing good living houses, in pleasant surroundings, for the people whom they employ. For the past seven years this firm has been practically wholly engaged on the erection of model villages in connection with large collieries. At present we have five villages in actual course of construction, as follows:—

	Probable Number of Houses required.	Number already erected.
Maltby Main Colliery Co., Maltby	1,400	950
Rossington Main Colliery Co., Rossington	1,500	500
Rother Vale Collieries Ltd., Thurcroft	1,000	300
Powell-Duffryn Steam Coal Co., Pengam	424	200
Hatfield Main Colliery Co., Hatfield	1,600	50

"'We are now preparing plans for three more villages, one in South Yorkshire, one in Lancashire, and one in Kent. The smallest of these schemes is for 424 houses, and the others approach 1600 houses. We have built houses in this way to the value of over one million pounds, without costing the colliery companies a penny, and have found it to be good paying business.

"'I therefore think that the proper solution of the housing problem is the formation of utility societies by the industrial companies. They are quite willing to undertake the building if the Government will advance the money at a fair rate of interest, and bear the loss over and above the Government guaranteed terms, so that they may have control of the houses. If the letting of the houses is vested in the local authorities, what security is there that the houses will go to the people for whom they are intended? It has happened that houses built by local authorities become inhabited not by the working classes but by persons of a higher position socially.'"

The best solution of the problem under present circumstances seems to be in the formation of public utility societies by employers and workmen.

As the "Committee on the Coal Trade after the War" state in their report:—

"If the large amount of housing accommodation necessary to meet the expansion of the industry is to be provided by the collieries, they should be given facilities to obtain the necessary capital on reasonable terms."

APPENDIX

COAL MINES ACT, 1911

RESCUE WORK

I.—MEMORANDUM ON SCHEMES OF TRAINING AND PRACTICE

UNDER the amending Rescue and Aid Regulations of 19th May 1914, the scheme of training for the Central Rescue Corps and the scheme of training and practice for the persons to be trained at each mine for the purpose of acting with the Corps, require to be approved by the Secretary of State. Schemes have now been drawn up after consultation with representatives of the industry who have taken a leading part in the organization of rescue work, and have been approved by the Secretary of State. At the same time, the scheme of training for rescue brigades under the earlier Regulations of 10th July 1913 has been revised to meet certain suggestions.

The schemes have been made as elastic as possible, and it is hoped that they will be found to meet all requirements. Should any variation be desired in any particular case, it will be necessary to submit it to the Secretary of State for his approval.

There are three points arising in connection with the new Regulations of 19th May 1914, and not covered by the schemes, to which it is desired to draw attention:—

(1) It seems very desirable that some of the periodical *practices* (after training) of the Central Rescue Corps should take place at the mines so as to familiarize the Corps with actual mining conditions. This is required by the earlier

Regulations in the case of rescue brigades, and would seem to be equally important in respect of the Central Corps.

(2) When men from the mines are being trained (under the scheme in Part I. (*b*) of the Order), it would be desirable that one or more trained members of the Central Rescue Corps should work with them during the first few practices (under, of course, the direction of the instructor) the presence and guidance of a fully trained man will give them confidence and help their training, and the association of the men from the Central Corps with the men from the mines is in itself an advantage to both.

(3) It will be of great importance that breathing apparatus provided in pursuance of paragraph (*d*) of No. 1 of the new Regulations should be the same at all the mines served by the same Rescue Station. The Regulations contain no express provision to this effect, but the need for uniformity in the matter is obvious, and it can no doubt be secured by arrangement between the parties concerned in the central station.

Where oxygen-breathing apparatus is used, care must be taken to ensure a high standard of purity in the oxygen used, and supplies, unless guaranteed by the manufacturers, should be tested by analysis. The Secretary of State is advised that it is not practicable entirely to exclude the presence of nitrogen, and that provided the nitrogen present does not exceed 2 per cent, the safety of the users of the apparatus will not be endangered. Oxygen containing a greater amount of nitrogen than 2 per cent, or any other impurity, would become a source of danger, and could not be regarded as complying with the requirements of the Regulations.

HOME OFFICE, WHITEHALL,
10th February 1915

II.—SCHEMES OF TRAINING AND PRACTICE APPROVED BY THE SECRETARY OF STATE

I hereby approve the following Schemes of training and practice for the purposes of the General Regulations relating to rescue work made under the Coal Mines Act, 1911 :—

PART I.—SCHEME UNDER GENERAL REGULATIONS OF 19TH MAY 1914

(a) *Central Rescue Corps*

The course of training shall consist of instruction and practices as hereinafter set out, and shall be continued until all the individuals comprising the corps are reported by the instructor to be efficient :—

(A) Instruction as to (i) the construction, use, repair and maintenance of the type or types of breathing apparatus provided for the corps, and of smoke helmets; (ii) the use of methods and apparatus for reviving men; (iii) the reading of mine plans; and (iv) the properties and detection of noxious and inflammable gases which may be found in coal mines.

(B) Practices—not less than twelve in number for each member—with breathing apparatus under conditions so devised as to represent those likely to be encountered in underground operations requiring the use of breathing apparatus. In respect of these practices the following rules shall apply :—

(1) The practices shall be carried out by at least five members of the corps at one and the same time.

(2) The training shall commence with practices carried out in ordinary air and shall progress gradually to practices carried out in a hot or irrespirable atmosphere.

(3) Each practice shall last at least two hours (unless in the opinion of the instructor it is desirable, in the interests of safety, to curtail the practices in respect of any member of the corps, or of the corps as a whole), and at some of the

practices the breathing apparatus shall be worn continuously during the practice.

(4) The practices shall comprise the following operations:—

(*a*) Raising, by means of a rope and pulley, a weight of 56 lb. to a height of 6 feet.

(*b*) Walking continuously at a fair pace for half an hour.

(*c*) Building and removing temporary stoppings of stone, brick, sandbags, brattice cloth, or other materials, and carrying the materials required for the same over a distance of at least 10 yards.

(*d*) Removing débris in confined spaces as representing the clearing of a fall of roof.

(*e*) Setting timber or other roof supports.

(*f*) Carrying, pushing, or pulling on a stretcher a live person or dummy body weighing 150 lb. along the length of the gallery, and through an opening 2 feet high by 3 feet wide and 4 yards long.

(*g*) The rapid establishment of telephonic communication.

(5) A record shall be kept of the date and character of each practice attended by a member of the corps, and the condition of each man after the practice, and, if anything abnormal is observed, it should be stated whether it is due to a defect of the apparatus or to the man himself.

(b) *Men from Individual Mines*

The course of training shall consist of instruction and practices as hereinafter set out, and shall be continued until the individual is reported by the instructor to be efficient:—

(*a*) The same instruction as in the scheme for the Central Corps.

(*b*) Practices with breathing apparatus under conditions so devised as to represent those likely to be encountered in underground operations requiring the use of breathing apparatus. In respect of these practices the following rules shall apply:—

(1) Each man shall undergo at least twelve practices in the first year. The training shall commence with practices carried out in ordinary air and shall progress gradually to practices carried out in a hot or irrespirable atmosphere.

Not more than eight nor less than five men shall take part in any practice, but if five men do not attend on any occasion the number may be made up by members of the Central Corps.

(2) Each practice shall last at least two hours (unless in the opinion of the instructor it is desirable, in the interests of safety, to curtail the practice in respect of any member of the set, or of the set as a whole), and at some of the practices the breathing apparatus shall be worn continuously during the practice.

(3) In the case of men coming from mines where smoke helmets are kept, two additional practices with smoke helmets shall be given.

(4) The practices shall comprise the same operations as are specified above for the Central Corps.

(5) After being reported to be efficient each man shall undergo at least one practice with breathing apparatus each quarter, which shall be carried out in a hot or irrespirable atmosphere.

(6) A record shall be kept of each person undergoing training or practice, the date and character of each practice attended, and the condition of each man after the practice, and, if anything abnormal is observed, it should be stated whether it is due to a defect of the apparatus or to the man himself.

PART II.—SCHEME UNDER THE GENERAL REGULATIONS OF 10TH JULY 1913

The course of training shall consist of instruction and practices as hereinafter set out. and shall be continued until all the members of the brigade are reported by the instructor to be efficient:—

(A) Instruction in the subjects mentioned in Regulation 140 (*d*) (iii).

(B) Practices—not less than twelve in number for each member—with breathing apparatus under conditions so devised as to represent those likely to be encountered in underground operations requiring the use of breathing apparatus. In respect of these practices the following rules shall apply:—

(1) The practices shall, as far as possible, be carried out by each brigade as such, i.e., by all members of the brigade at one and the same time.

(2) The training shall commence with practices carried out in ordinary air, and shall progress gradually to practices carried out in a hot or irrespirable atmosphere. Each practice shall last at least two hours (unless in the opinion of the instructor it is desirable, in the interests of safety, to curtail the practice in respect of any member of the brigade or the brigade as a whole), and at some of the practices breathing apparatus shall be worn continuously during the practice.

(3) The practices shall comprise the same operations as are specified in Part I. for a Central Rescue Corps.

(4) A record shall be kept of each person undergoing training, the date and character of each practice attended, and the condition of each man after the practice, and, if anything abnormal is observed, it should be stated whether it is due to a defect of the apparatus or to the man himself.

R. McKENNA,
One of His Majesty's Principal
Secretaries of State

HOME OFFICE,
18*th January* 1915

III.—GENERAL REGULATIONS OF 19TH MAY 1914

In pursuance of Sections 85 and 86 of the Coal Mines Act, 1911, I hereby make the following regulations amending the General Regulations made under the said Act and dated July 10, 1913:—

Special Provisions for Mines served by a Central Rescue Corps

1. Nos. 140, 141, and 142 of the General Regulations above mentioned shall not apply to any mine which is served by a central rescue station maintaining a permanent rescue corps, and which is situated within a radius of ten miles from the station and is in telephonic communication with it, subject to the following conditions:—

(*a*) The rescue corps at the central station shall consist of not less than six men, or if the total number of underground employees at all the mines served by the station in pursuance of this regulation exceeds 15,000, eight men.

The members of the corps shall be carefully selected on the ground of their coolness, powers of endurance, and general suitability for the work, and shall be medically certified to be fit for the work; and they shall hold a certificate of proficiency in first aid from a society or body approved by the Secretary of State.[1]

They shall be continuously employed and in constant residence at the station.

The corps shall be thoroughly trained in the use of breathing apparatus and in rescue work in accordance with a scheme approved by the Secretary of State and shall be constantly kept in a highly efficient state.

One or more members shall be appointed to act as leaders.

(*b*) One or more persons employed at the mine for the time being shall be selected for the purpose of acting with the rescue corps from the central station when summoned, as follows:—

---

[1] The First Aid Certificates of the St. John Ambulance Association, the St. Andrew's Association, the Heriot-Watt College, and the Glamorganshire Education Committee have been approved by the Secretary of State.

If the total number of underground employees is not less than 100 nor more than 250	Not less than 1 person.
If the total number of underground employees is more than 250 but not more than 1000	Not less than 3 persons.
If the total number of underground employees is more than 1000	Not less than 5 persons.

They shall be thoroughly trained, and shall from time to time undergo practices, at the central station, in the use of breathing apparatus and in rescue work in accordance with a scheme approved by the Secretary of State.

They shall be carefully selected on account of their knowledge of the mine, coolness, and powers of endurance, and shall be medically certified to be fit for the work, and shall hold a certificate of proficiency in first aid as above mentioned.

Subject to the limit of number specified above, so far as reasonably practicable at least one shall be selected from each shift.

Arrangements shall be made for summoning such persons immediately their services are required.

No breach of condition (*b*) shall be deemed to have arisen in consequence of failure to maintain at the mine the full number of trained men in accordance with the foregoing provisions if the owner, agent, or manager of the mine satisfies the Inspector of the Division that he had made every effort to comply with those provisions and that the failure was due to causes over which he had no control.

(*c*) There shall be kept at every mine tracings of the workings of the mine up to a date not more than three months previously, showing the ventilation and all principal doors, stoppings and air crossings, regulators and telephone stations, and distinguishing the intake air by a different colour from the return air, which tracings shall be in a suitable form for use by the corps.

(*d*) There shall be provided and maintained at the mine:—

(i) Two complete suits of breathing apparatus or two smoke helmets (that is, appliances for supplying fresh air to the user by means of a pipe and bellows), or one of each in an efficient state and constantly ready for immediate use.

(ii) Two or more small birds or mice for testing for carbon monoxide.

(iii) One electric hand-lamp and one safety lamp for testing for firedamp for each person trained in pursuance of condition (*b*) above.

(iv) One oxygen-reviving apparatus.

Definition of "breathing apparatus"

2. For the purpose of the foregoing regulation and of Part IV. of the General Regulations above mentioned, breathing apparatus means an apparatus of such a character that the wearer carries with him all the means for respiration in an irrespirable atmosphere, and is not dependent for them, while in such an atmosphere, on any other person or persons.

R. McKENNA,
One of His Majesty's Principal
Secretaries of State

WHITEHALL,
19*th May* 1914

IV.—GENERAL REGULATIONS OF 10th JULY 1913

In pursuance of Section 86 of the Coal Mines Act, 1911, I hereby make the following Regulations, . . .

. . . .

. . . .

138. The following Regulations shall apply to all

mines in which coal is worked, provided, however, that the Secretary of State may, if he thinks fit, exempt from the Regulations any mine at which the total number of underground employees is less than 100 if the mine is so situated that in the opinion of the Secretary of State the organisation of a Central Rescue Station from which it could be served is impracticable.

139. No person, unless authorized by the manager or official appointed by the manager for the purpose, or, in the absence of the manager or such official, by the principal official of the mine present at the surface, shall be allowed to enter a mine after an explosion of firedamp or coal-dust, or after the occurrence of a fire, for the purpose of engaging in rescue work.

140. (*a*) There shall be organized and maintained at every mine, as soon as is reasonably practicable, competent rescue brigades on the following scale:—

Where the number of underground employees is 250 or less	1 brigade
Where the number of underground employees is more than 250 but not more than 700	2 brigades
Where the number of underground employees is more than 700 but not more than 1000	3 brigades
Where the number of underground employees is more than 1000 ...	4 brigades

But the owner, agent, or manager of a mine, at which the total number of underground employees is less than 100, shall be deemed to have complied with this provision if he has acquired the privilege of calling for a brigade from a Central Rescue Station.

A group of mines belonging to the same owner, of which all the shafts or exits for the time being in use in working the mines lie within a circle having a radius of two miles, shall, for the purpose of ascertaining the number of brigades required, be treated as one mine.

(*b*) A rescue brigade shall consist of not less than five persons employed at the mine, carefully selected on account of their knowledge of underground work, coolness and powers of endurance, and certified to be medically fit, a majority of whom shall be trained in First Aid and shall hold a Certificate of the St. John Ambulance Association or the St. Andrew's Association or other society or body approved by the Secretary of State.[1]

(*c*) There shall be selected from the ranks of each rescue brigade one person or leader who shall act as captain of the brigade.

(*d*) A brigade shall not be deemed competent unless (i) it undergoes a course of training approved by the Secretary of State; (ii) after the preliminary course of training it undergoes in every quarter at least one day's practice with breathing apparatus, which practice shall at least twice in the year take place at the mine; (iii) the members of the brigade shall have received instruction in the reading of mine plans, in the use and construction of breathing apparatus, in the properties and detection of poisonous or inflammable gases, and in the various appliances used in connection with mine rescue and recovery work.

(*e*) Arrangements shall be made at every mine for summoning members of rescue brigades immediately their services are required.

141. If it can clearly be proved that the necessary number of persons employed underground at a mine will not consent to form a brigade or brigades, or having offered their services fail to be trained or maintain their training, the owner, agent, or manager of the mine shall not be liable to any penalty provided first that he has endeavoured to the best of his ability to constitute the requisite brigade or brigades, and has afforded every opportunity to the persons employed at the mine to undergo the necessary training, and secondly that he has made a *bonâ fide* attempt to arrange for the supply from a Central Rescue Station of such rescue brigades as he is unable to provide at his mine.

[1] See page 240.

42. (*a*) There shall be provided and maintained at every mine suits of portable breathing apparatus in the proportion of two suits to each brigade required by Regulation 140 (*a*). The apparatus must be capable of enabling the wearer to remain for at least one hour in an irrespirable atmosphere, and must be kept ready for immediate use. The apparatus must be housed in suitable receptacles in a dry and cool room.

The owner, agent, or manager of a mine shall be deemed to have complied with this requirement if he has acquired the privilege of calling for such of these appliances as he may not possess from a Central Rescue Station, always provided that the Central Rescue Station is situated within a radius of ten miles from the mine and is in telephonic communication with the mine.

(*b*) There shall be kept at every mine tracings of the workings of the mine up to a date not more than three months previously, showing the ventilation and all principal doors, stoppings and air crossings, regulators and telephone stations, and distinguishing the intake air by a different colour from the return air, which tracings shall be in a suitable form for use by the brigades.

(*c*) There shall also be provided and maintained at every mine which maintains a rescue brigade or brigades—

(i) Two or more small birds or mice for testing for carbon monoxide.

(ii) Two electric hand-lamps for each brigade, ready for immediate use and capable of giving light for at least four hours.

(iii) One oxygen-reviving apparatus.

(iv) A safety lamp for each member of the rescue brigades for testing for firedamp.

(v) An ambulance box provided by the St. John Ambulance Association or similar box, together with antiseptic solution and fresh drinking water.

143. There shall be kept and maintained in every Central Rescue Station not less than fifteen complete suits of breathing apparatus, with means of supplying sufficient

oxygen or liquid air to enable such apparatus to be constantly used for two days and of charging such apparatus; and

Twenty electric hand-lamps;
Four oxygen-reviving apparatus;
An ambulance box or boxes, provided by the St. John Ambulance Association, or similar boxes, together with antiseptic solution and fresh drinking water;
Cages of birds.

A motor car shall be kept in constant readiness.

144. Every Central Rescue Station shall be placed under the immediate control of a competent person conversant with the use of the appliances.

145. There shall be adopted at every mine by the owner, agent, or manager such Rules for the conduct and guidance of persons employed in rescue work in or about the mine as may appear best calculated for the carrying out of rescue operations, and the rescue brigade or brigades, if any, maintained at the mine shall be thoroughly instructed in such Rules.

146. "Central Rescue Station" means a station established to serve several collieries.

R. McKENNA,
One of His Majesty's Principal
Secretaries of State

HOME OFFICE, WHITEHALL,
10*th July* 1913

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